COMMUNITY HEALTH

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THIRD EDITION

APPLETON-CENTURY-CROFTS, INC.
New York

499

MANUFACTURED IN THE UNITED STATES OF AMERICA

PREFACE TO THIRD EDITION

This book was written for use in college courses in community hygiene or community health. It has met with a certain amount of success but, because the health picture in any community has changed so much since 1934 when the first edition (entitled *Community Hygiene*) appeared, it was thought necessary to revise the text completely and rearrange the units to give proper emphasis to the various topics discussed. The title has been changed to *Community Health* as being more descriptive of the range of the volume. Much new material has been added and some which has become obsolete has been removed. Many communicable diseases have come under a high degree of control and newer problems have become more prominent. In the present discussion we have attempted to consider many of the newer ideas insofar as present knowledge can contribute to a solution. Because many factors in the newer health problems are still unknown, a rather unsatisfactory situation exists in this regard. On the other hand, almost constant advance is noted in the daily press, on the radio, and in magazines. If a firm groundwork is laid in a general course in health, the average student should be able to appreciate the significance of the discoveries he hears and reads about.

The subject of hygiene is of practical importance. Because of ignorance or carelessness, many people who could be saved, still die too young. Any knowledge that general health education can contribute to human conservation with consequent prolongation of life, comfort, or efficiency should be worth while.

There are cultural aspects of the subject which should receive more attention than they do. Certain significant historical events of a medical nature are mentioned from time to time in the text. These should contribute to the student's general information and background. Such facts are seldom presented in general courses in history; they are, however, important in the development of western civilization and should not be ignored by the well-informed student.

Much of the statistical material used in the various charts in the

text was obtained from the very excellent records of the Cincinnati Board of Health which we used for several reasons. Vital statistics for the nineteenth century were difficult to obtain from national sources; in order to give a continuous picture as far back as possible, a smaller than national or state health unit was chosen. The statistics were readily available to us because of the excellent condition of the records. Certain factors in the local health situation were obtainable from records of various other organizations and from the memory of different individuals consulted. Cincinnati is a fairly typical American community; its health situation is sometimes better and sometimes worse than the national average. Many of the health problems were solved as indicated in the various charts shown in the text, some were improved, while others remained unsolved. The Cincinnati Health Department is well organized and administered. The various specialists of that department spent time with us and gave generously of their advice. We are indebted to them.

The officials of the Cincinnati Water Works supplied us with drawings and descriptions of these works which were valuable contributions to our text. We are also indebted to them. These water works are excellent examples of engineering skill and accomplishment. When one considers that water of the grossly polluted Ohio River is purified and delivered to the citizens of the town in usable form the degree of accomplishment can be appreciated and the method can be recommended as efficient.

Finally we wish to thank our many friends for the suggestions they have made. We tried to incorporate as many of their ideas as possible in this present edition.

L.B.C.
W.R.M.

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1

HYGIENE AND HEALTH EDUCATION

Definitions: The term "hygiene" is of ancient origin and is derived from a Greek root meaning "health." Hygieia was the Greek goddess of health; she was called by the Romans "Valetudo." The English word health is derived from the Anglo-Saxon word "haelth" and is practically synonymous with hygiene. In common usage hygiene is often considered as the body of scientific facts relating to the health or well-being of the individual or group. Inasmuch as disease is the antithesis of health, the study of health usually requires the study of disease just as an appreciation of what is "good" requires a consideration of what is "evil."

General hygiene may be thought of as the rational or logic of health that gives the fundamental laws upon which health is based and presents the accumulated scientific facts covering the cause-and-effect sequences of health. It furnishes knowledge from which man learns to improve, modify, conserve, or defend his health.

There are many subdivisions under the main heading of general hygiene such as personal or individual hygiene, which has to do with matters of health for which the individual person must assume responsibility, or public health or public hygiene, which deals with health matters pertaining to the group or community for which government usually assumes responsibility.[1] Other divisions are industrial hygiene, which is concerned with the promotion of health by labor groups and industry, and educational hygiene or school hygiene, which is involved with health promotion in schools, the education of students in healthful living and many other activities. There are many other terms in modern usage such as oral hygiene, mental hygiene, and social hygiene.

[1] Many public health activities are performed by voluntary health organizations when the community so wishes.

Unfortunately, in the minds of many people, the term hygiene has come to mean mere cleanliness when, in reality, its classical meaning is that of the science of prevention of disease and promotion of health.[2] Hygiene is a medical science, thought of as the prevention rather than the cure of disease; hence the term "preventive medicine" is often used in this connection.

Health is a Relative Attribute: The sense of well-being or freedom from illness, or symptoms of illness, which is usually called health, is not absolute but relative. Perfect health is, in reality, an abstraction and probably unattainable. It can be approached, however, and for practical purposes the individual can be said to be healthy when he is free of subjective symptoms, objective defects, and diseases. In modern usage a change in concept is taking place and health has come to mean more than mere freedom from disease. As Dr. Stieglitz says, "Optimum or perfect health implies maximum reserve capacity for each and every structure and function of the organism." [3] This applies to every aspect of health including the mental, emotional, and physical. The body is a unit and weakness in any part affects the whole.

There are two classes of modern medical specialists who have practiced this concept more than any of the others, the pediatricians and the obstetricians. The pediatrician often starts his studies and observations just after the birth of a baby and continues them until the child reaches puberty, as a rule, when he expects to pass him on to another physician. The obstetrician follows the expectant mother from the time she comes to him, through the period of gestation, labor, delivery of the baby, and the puerperium. In these two fields of medicine, the results have astonished the most sanguine advocates of the practice. By making positive suggestions, based on scientific knowledge, pediatricians have been able to improve the immature organism, and obstetricians have likewise been able to improve the health of the young mother to a noticeable degree.

Constructive Medicine: A new practice is gradually coming into medicine which is concerned with more than the curative and preventive aspects so well known today. The idea behind the practice

[2] See Stieglitz, E. J. *A Future for Preventive Medicine,* p. 3, New York, The Commonwealth Fund, 1945.

[3] *Ibid.,* p. 4.

is that "the prevention and cure of disease will fall into their proper place as subsidiary and not primary objectives and medicine will become constructive rather than remedial or preventive." [4] The term "Constructive Medicine" has been proposed for this idea [5] which is gaining acceptance by those who might be called medical philosophers.

Constructive medicine is in its infancy. There are not enough known facts at hand concerning its principles and practices to fill even a small pamphlet. No doubt the future will reveal the answers to many perplexing problems of the present day.

Definition of Health Education: Health education is considered here as "the sum of experiences in school and elsewhere which favorably influences habits, attitudes, and knowledge relating to individual, community, and racial health." [6] The field covered is broad and includes more than instruction in formal or informal activities pertaining to health. Health practices in the life of an individual, or in a community, are the expressions of a number of factors, including habits and attitudes, as well as knowledge. In every day living most people fall below what they know to be the best in health practice. This explains why health education includes all of those factors which influence and modify health conduct. The state of one's health determines, to a large degree, the type and quality of work done by man. On the other hand, the activities and conditions under which one works affect one's health in no small degree. This is clear when the definition of health considers the body as a unit with the mental and emotional as well as the physical processes functioning normally.

This interplay between man and his environment is so great and the influences affecting his health so numerous and varied that it is almost impossible to limit the field of health education by any well-defined boundaries. In addition to the organized and formal activities found in a community, there will always be innumerable ill-defined influences affecting and adding to the "sum of experiences" related to health. This is especially true out in the periphery of the field as it is understood and organized today.

[4] Smith, G. and Evans, L. J. "Preventive Medicine: An Attempt at a Definition." *Science,* v. 100, p. 39, 1944.

[5] Stieglitz, E. J. "Pertinent Problems of Geriatric Medicine." *Annals of Internal Medicine,* v. 18, p. 89, 1943.

[6] Wood, T. D., and Rowell, H. G. *Health Supervision and Medical Inspection of Schools,* p. 36. W. B. Saunders Co., Philadelphia, 1929.

Health Education in the Community: There are many community organizations interested in health education. The public health department and the public schools are two important official organizations. In addition, there are numerous non-official or voluntary agencies. The growth of the work in health education, as in other fields of health, has been slow and, until recent years, without any general direction. Even in the schools the program developed irregularly and today there is great variation in the type and quality of the work done. Some organizations developed locally while others were national in scope and character. In either case, however, the agency or program usually grew out of an interest in meeting some special health problem. For example, The National Tuberculosis Association is the result of an attempt to reduce the danger from tuberculosis. The American Cancer Society grew out of an interest in combating cancer. The growth of these agencies has been rapid and marked during the last twenty-five years. Today their number is large and they exist on many levels. They include small and large areas and small and large groups of people. Certain difficulties accompanied this multiplication of organizations. There was duplication of effort, overlapping of interests, difficulty in raising funds and, in many cases, a lack of co-operation among the personnel involved. Many of these problems are solved today by co-ordinating all of the different and various agencies into one organization. The name of this organization may be different in each case but the purpose is the same, namely, that of co-ordinating the various agencies into one co-operating unit. Under such a plan the health needs of the community are studied by a central committee or council and then directed to the particular agency best fitted to assume that responsibility. The health of a community should be the concern of all its citizens and, at times, individuals, families, and groups outside the health organization may be able to render valuable service in the solution of some health program. Their services may be enlisted through the co-ordinating organization. It is desirable to have people work on their own problems developing, as far as possible, leaders from their own groups. Lay and professional groups must work together.

The number of co-operating agencies working under such a plan in the larger cities is impressive. There are ninety-five agencies in the membership of the Cincinnati Public Health Federation. Fifty differ-

ent organizations co-operate with the Cleveland Health Council. There are forty or more national organizations interested in health. Some of these organizations are interested in relieving suffering, others in medical care, and others in purely educational work. But all, even those doing practical work, must as a corollary from their work educate in matters pertaining to health. Education is an important part of the Anti-Tuberculosis League. The Red Cross gives formal and informal courses in hygiene as well as first aid and life-saving. The Social Hygiene Society attempts to arouse mankind to the significance of venereal disease and to give instruction in hygienic practices in legitimate sex relationships. Health education is a definite part of the activities of the Children's Fresh Air Camp and Hospital. The Academy of Medicine is interested in spreading scientific information about health. Thus it is evident from these examples, that health education is a vital concern of practically all health agencies. It may be said that of all the aims in health work, health education is the most important one of all. Because of this common interest the modern coordinating agency uses every available means of publicity in its educational campaign. Reference is now made to radio, movies, written articles, public addresses, exhibits, and others.

Health Education in Schools: The schools are community organizations but because of their importance in a health education program they are considered separately. In most towns, cities, and in some rural communities there are organized health activities centered and administered in the public schools. School officials are especially conscious of the aims and purposes of health education because of the opportunity for developing attitudes of personal responsibility for individual and community welfare early in the life of the school child. As in the community, health education may be extended into practically all the activities of the schools.

There are a number of aspects in a modern school health program. One of these is health instruction. The principles followed are the same as those used in the community program. The child is taught directly through formal classes in health and integrated teaching in other school subjects, and indirectly through other experiences and activities in the school.

Classes in hygiene comprise most of the organized teaching. The theory of teaching health through integration with other subjects such

as physical education, history and chemistry, for example, is sound but because of the difficulties encountered it is not commonly practiced to any extent. This is unfortunate because health is one of those "over-all" aims along with character, appreciation of the beautiful, and others in which all teachers should be interested and be willing and glad to promote as far as their particular subject will permit. In most subjects there are some and in some subjects there are many opportunities to promote the teaching of health. In this connection it should be noted that much of interest and value in such subjects as history and literature may be taught in hygiene.

The content of health courses will vary according to the needs, interests, age, and previous training of the students. However, the aim of creating an ideal and purpose for living wholesomely will remain the same in each grade. In the modern school the health education program is carefully organized for the children at each grade level. Although the classroom or home room teacher occupies the key position in the general health program, the health classes are frequently taught by another such as the teacher of physical education, general science, home economics, the school nurse, and others who have had special training in the field of health.

Health service is another division of health education. Included here are health examinations, morning inspection, inoculation against disease, first aid and others. These activities may contribute greatly to the general health education program. Through these experiences the child learns health standards and values by example and practice. Because the student has a personal interest in the service being rendered, the opportunity to teach health is excellent and is not equalled in any other aspect of the whole health education program. Unfortunately there is usually such a rush of work that there is not time to take advantage of this golden opportunity. Waiting crowds of students too frequently make it necessary to dispatch such service as quickly as possible. The most satisfactory teaching in this connection can be done only through special individual conferences with each student. The results of sitting down alone with the student and talking over informally his health problems is time well spent.

In addition to health instruction and health service, health education includes health supervision. The health of the child is materially affected by the school environment in which he spends several

hours each day. From this experience he acquires ideas as to what conditions are favorable to health. Reference is now made to such items as the sanitation of buildings and grounds in general, heating, ventilation, lighting, water supply, sewage and refuse disposal, and school lunches. All environmental factors should be included.

Health education in the schools has had the same slow, irregular, and rather haphazard growth as that found in the community. It has followed no generally accepted plan. There is also the same need for co-ordination of the various departments and agencies in the schools which are in a position to contribute to the health education program. Some of the community health organizations, both official and nonofficial in character, are able to render valuable aid to the school program and provision should be made for including them in any plan of co-ordination. This need has been met in some schools by the appointment of a representative health committee whose function it is to co-ordinate the work of the various school and community organizations and to promote co-operation between teachers, administrators, custodians, students, and health workers in the community. A recent development along this line has been the employment of a specialist in the field known as the health educator who assumes the responsibility for directing the work in health education. If health, the first of seven cardinal principles set forth by the National Education Association, is to be fully realized the school must have a health program and it must function effectively.

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2

HEALTH CONDITIONS IN THE UNITED STATES

Early Health Conditions: At the time of the organization of this country there were no scientific statistics collected from which the present-day student could get an idea of health conditions. Infectious diseases such as diphtheria, smallpox, typhoid fever, and tuberculosis were common and taken as a matter of course. Epidemics of cholera, yellow fever, and other conditions uncommon today frequently broke out. Such epidemics decimated the population and alarmed the people. (See Fig. 1.) A heavy toll was taken among young people particularly and the life expectancy at birth was probably between 20 and 25 years in 1800. In spite of the high death rate, the population grew steadily, due, no doubt, to an abnormally high birth rate. The life expectancy being short, young children predominated in all communities.

More than nine-tenths of the people lived in the rural sections distributed along the Atlantic seaboard. The majority were farmers, who produced most of what they consumed, and were separated in sparsely settled communities where overcrowding was not common. The independent farmer felt little need for community agencies to protect his health and he provided the rudimentary sanitation of his own environment. There were no organized efforts toward health conservation at the beginning of the nineteenth century. Indeed, in the recently adopted Constitution of the United States the world "health" did not appear. There was no provision made for its promotion or preservation. Physicians were poorly trained as the medical schools of the time were few and inadequate.[1] New physicians were trained by

[1] The medical schools in 1800 were: University of Pennsylvania (founded in 1765), Harvard University (1782), Dartmouth College (1798), and The College of Physicians and Surgeons of New York (1798).

an apprentice system. Medicine was largely traditional and, in the light of what is now known, was very inadequate. Bleeding and purgings were used for practically all illnesses. These forms of treatment usually did no good and often much harm.

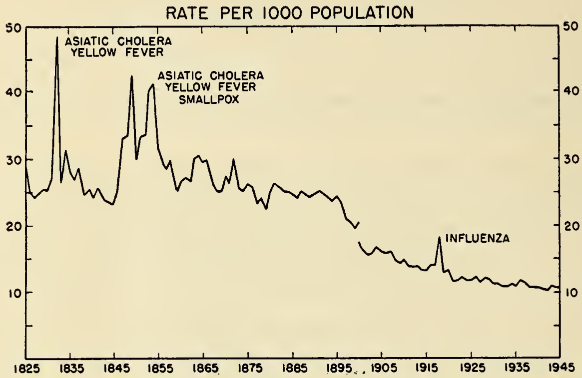

Fig. 1. Crude Death Rate, All Causes, United States. Rates for the 19th Century were derived from the cities Boston, New York, Philadelphia, and New Orleans. (Rates for rural areas were not available until after 1900.) Rates for the 20th Century are for the Registration Area of the United States. Various epidemics are indicated. (See Fig. 103 for the Registration Area of the United States at various times.)

At the beginning of the nineteenth century the only specific prophylactic measure in common use was against smallpox. Cowpox vaccination, discovered in England, was introduced into Massachusetts in 1800 by Dr. Benjamin Waterhouse.

Beginnings of Modern Health Movements: Scientific health practices in the United States lagged far behind those of Europe. The more progressive and scientifically minded physicians in this country attended clinics abroad and studied under European masters.

The American Medical Association was founded in 1847 to improve medical education. As time passed this Association assumed other activities until it now has many bureaus intimately concerned with the health of the people.

In 1850 Lemuel Shattuck, statistician and genealogist, wrote a report

public health

for the Massachusetts legislature.[2] The report contains the results of an investigation of sanitary conditions in Massachusetts with fifty recommendations for the improvement of the health conditions of the people of that state. Most public health workers have considered this the moving force which initiated the public health movement in this country.[3]

Modern hygiene developed as a result of discoveries of Louis Pasteur, Robert Koch, and others, which began about 1876. Before that time many incorrect ideas of disease causation prevailed. Pasteur had previously discovered that fermentation was caused by microscopic organisms developing in solutions of sugar (1858). Later it was recognized that an analogy exists between fermentation and infectious disease.[4] (See Chapter 3.)

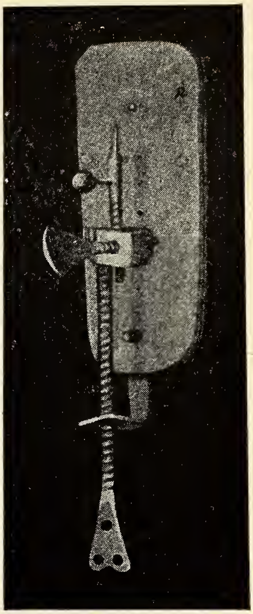

Fig. 2. A simple microscope made by Leeuwenhoek (actual size). This instrument magnified objects about 160 diameters but, by superior skill in its use, Leeuwenhoek was able to describe the microscopic structure of protozoa and bacteria. (See Fig. 15.)

The study of microorganisms was made possible by the development of the modern forms of the microscope. Simple microscopes were devised in antiquity but greatly improved by Anton von Leeuwenhoek in the Eighteenth Century. One of his microscopes is illustrated in Figs. 2 and 3. The compound microscope was invented by Hans and Zacharias Janssen as early as 1590 and improved by Benjamin Martin between 1760 and 1776. The oil immersion-

[2] *Report of the Sanitary Commission of Massachusetts.* Boston, Dutton and Wentworth, State Printers, 1850. (A facsimile edition printed by offset-lithography from the pages of the original edition with a foreword by Charles-Edward Amory Winslow was published by the Harvard University Press, Cambridge, in 1948.)

[3] See Mustard, H. S. *Government in Public Health,* p. 92, New York, The Commonwealth Fund, 1945.

[4] See *The Physiological Theory of Fermentation,* by Louis Pasteur in the *Harvard Classics,* edited by Charles W. Elliot, v. 38, p. 289, New York, P. F. Collier and Son, 1910. Also *idem, The Germ Theory and Its Application to Medicine and Surgery,* (Read before the French Academy of Sciences, April 29, 1878) p. 382. *Idem. On the Extension of the Germ Theory to the Etiology of Certain Common Diseases.* (Read before the French Academy of Sciences, May 3, 1880.) p. 390.

lens microscope was invented by Ernst Abbé in 1886. A modern version of this type microscope is illustrated in Fig. 4. Fig. 5 shows the latest development in microscopy, the electron microscope. This instrument can enlarge the microbe of tuberculosis to the size of a large loaf of bread.

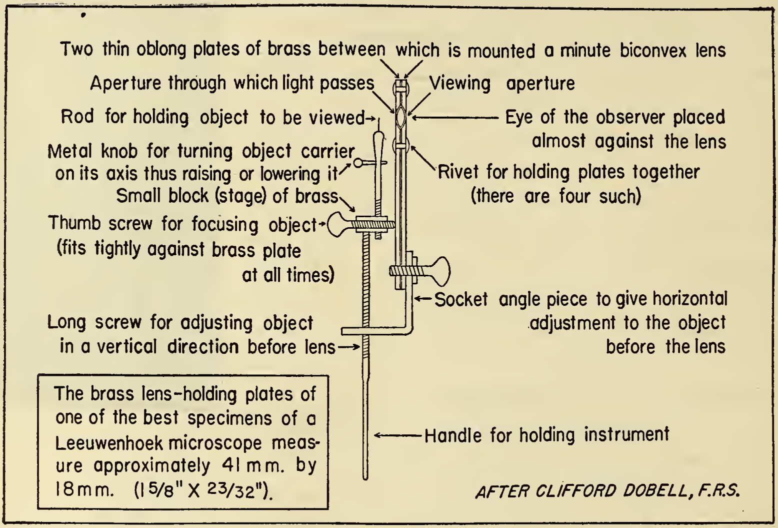

FIG. 3. Diagram of the lateral view of the microscope shown in Fig. 2. Objects to be examined were placed on the point of the rod before the lens. It is not known exactly how all objects were held in place. It has occurred to the authors that bacteria may have been studied in a hanging drop of water with the instrument held upside down.

Development of means of culture of bacteria in the laboratory, initiated by Robert Koch, led to the discovery that most infectious diseases could be produced by injecting cultures of micro-organisms into susceptible animals. This also led to the development of the science of immunology in which Pasteur was the undisputed leader.

Studies in the modes of transmission of communicable diseases led to marked improvement in health. The degree of improvement cannot be accurately judged as reliable statistics did not exist in the United States before 1900. About that time water supplies began to be purified by filtration and decrease in water-borne disease took

place (see Fig. 59). Specific immunization against diphtheria was developed in Germany (1913) and that disease began to come under control. (See Fig 32.)

Health in the Twentieth Century: There has been the greatest saving of lives through disease prevention of all time in the last half century. The factors involved have been several and varied. The first major condition to show a marked drop in morbidity and mortality was typhoid fever, a disease prevalent throughout the nineteenth century. (See Figs. 56 and 59.) In 1900 its mortality rate was 26.8 per 100,000 population. Today it is less than 0.3 per 100,000. This was the result of extended water purification, improved sewage disposal in many communities, and the specific immunization of millions of people from 1918 to the present time. Diphtheria mortality was 32.8 per 100,000 in 1900; today it is less than 1.0 and there are many large communities with no deaths from this disease. Such improvement has been the re-

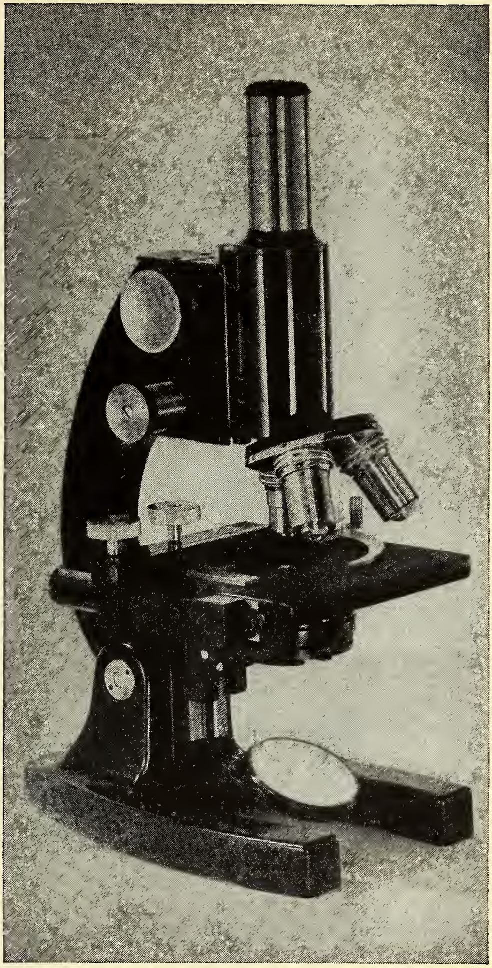

Fig. 4. A modern compound microscope. Bacteria are viewed directly by being mounted on a slide, stained, held in place on a "stage" and the lens moved to focus on them. Magnification may be upwards of 1,000 diameters. In Leeuwenhoek's microscope, shown in Figs. 2 and 3, the "stage" was moved while the plates holding the single lens remained fixed.

Courtesy Bausch and Lomb Optical Co.

sult of specific treatment with diphtheria antitoxin and widespread immunization with diphtheria toxoid. (See Fig. 32). Diarrhea and enteritis mortality has diminished from 116 per 100,000 in 1900 to less

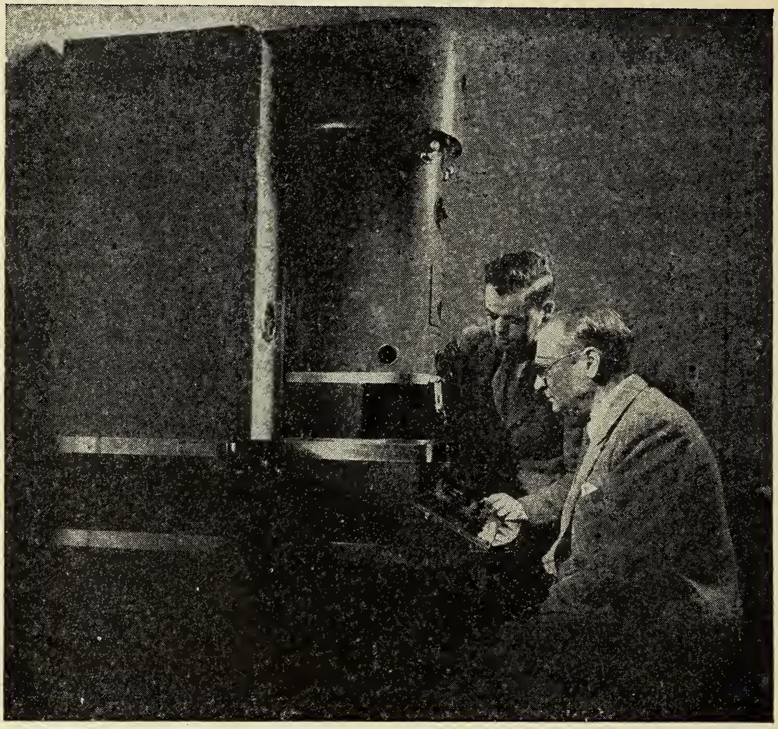

FIG. 5. The RCA Electron Microscope is shown here with its inventors— (right) Dr. Vladimir K. Zworykin, Vice President and Technical Consultant of RCA Laboratories and Dr. James Hiller (left) of the Laboratories staff. The electron microscope is capable of magnifications up to 180,000 diameters.

Courtesy Radio Corporation of America

than 9, also largely because of water purification, pasteurization of milk, and greater attention to prevention. Through the practice of preventive pediatrics, mothers have been instructed by physicians and public health nurses as to the causes, modes of transmission, and prevention of this condition. (See Figs. 56, 77 and 103.)

Practically all air-borne disease has showed a marked decrease in

the last half century. This is the subject of an interesting monograph.[5] In the case of scarlet fever, where the practice of specific immunization has been disappointing, the older methods of isolation and quarantine have apparently produced results. (See Fig. 96.) Even where no specific prophylaxis exists, as in the case of tuberculosis, improved methods of early detection, such as mass X-rays and tuberculin testing, and widespread use of sanatorium treatment, which isolates the patient from susceptible contacts, have caused marked improvement in this disease. (See Fig. 44.) No doubt the bettering of social and economic conditions of all the people, which has occurred in recent years, together with better techniques in treatment, have played a prominent part in this improvement.

Pneumonia had a death rate of 161.5 per 100,000 for the five years 1900-04; today it rarely exceeds 40. There are no specific preventive measures against pneumonia but sulfonamide drugs, penicillin, and aureomycin have proved markedly effective in the treatment of most members of this group of diseases. The reduction in the death rate has occurred by reason of the marked reduction in the case fatality rate. In all probability, just as much pneumonia as ever occurs but the antibiotics are so effective in its treatment that deaths are avoided.

preventive medicine

Surgical advance has been marked in the twentieth century and such conditions as acute appendicitis have shown marked decrease in mortality. In addition to this, the public has become better informed about this disease and others and is not so apt to delay necessary treatment. A part of the advance in surgery has been made possible by the excellent development of anaesthesia as a speciality.

Since 1911 dietetic deficiency diseases have become recognizable as such and the diet of the American people has improved through education in nutrition. It is not possible, at this time, to prove that improvement in nutrition has led to increased general resistance to disease but such is probably the case.

The profession of dentistry has developed rapidly in recent years. Although an ancient art and practiced to some extent in Egypt and Greece before the Christian era, it had not reached the status of a medical profession until the present century. It is now regarded as the oral specialty of medicine which has accomplished much for the

[5] O'Hara, Dwight. *Air-Borne Infection: Some Observations on Its Decline.* New York, The Commonwealth Fund, 1943.

general health of the people. Two important contributions to general health have been the prevention of tooth decay (to some extent) by the use of sodium fluoride, and the removal of devitalized teeth as foci of infection. In addition, by improved techniques in diagnosis and treatment the dentist is able to contribute to the general health of the individual in other ways. General nutrition is enhanced by the individual's having a good set of teeth for mastication. The dentist is often able to point out dietary deficiencies or disturbances of a general nature by findings in the teeth seen at regular inspections.

The greatest improvement in health among the American people in the past 50 years has been among infants under one year of age. The mortality rate for infants under one year of age fell from 162.4 per 1000 live births in 1900 to 54.9 in 1940. However, only a moderate decline occurred for adults between fifty-five and sixty-four from 27.2 to 22.3 per 1000 in that age group in the same years.[6]

Life expectancy has increased in all age groups as shown in Table I. Table II gives the expectation of life at the various ages for 1946. The greater part of this gain is due to improved sanitary and public health practices but a large part is also due to increased skill in medical and surgical practice, improved social developments which result in better housing, higher standards of living, less overcrowding, technological developments which produce better and safer conditions of work, travel, and home life, as well as many other factors. Added to all these are the remarkable advances made in the profession of pharmacy. At the present time there is an impressive array of highly purified drugs, insecticides, disinfectants, and antibiotics available to the people of the United States. Technological developments in electric power, means of transportation, telephone communication, production of countless articles of value in health promotion should not be minimized as they contribute greatly to all the improvement noted above.

One of the most striking developments of this time is the increase in number and efficiency of hospitals. In 1880 there were only 180 institutions, serving about 146,000 patients, listed as hospitals. In 1933 there were 6,437 hospitals in the United States with over a million beds. By 1943 the bed capacity of hospitals in this country had in-

[6] U. S. Department of Commerce, Bureau of the Census. *Vital Statistics, Special Reports,* v. 16, no. 2, p. 9, July 8, 1942.

Table I

Increase in Life Expectancy: White Males and Females

Years	At birth		At age 20		At age 45		At age 70	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*	*Males*	*Females*
1900–1902 *	48.2	51.1	42.2	43.8	24.2	25.5	9.0	9.6
1919–1921 †	56.3	58.5	45.6	46.5	26.0	27.0	9.5	9.9
1929–1931 §	59.1	62.7	46.0	48.5	25.3	27.4	9.2	10.0
1939–1941 §	62.8	67.3	47.8	51.4	29.5	28.9	9.4	10.5

Source: U. S. Bureau of Census.
* For original death-registration area (26.2% of national population).
† For death-registration area of 1920 (80.9% of national population).
§ Since 1933 100% of deaths have been recorded (See Fig. 105).

Table II

Expectation of Life in the United States at Specified Ages by Color and Sex, 1946

Age	*Total persons*	*White*		*Colored*	
		Males	*Females*	*Males*	*Females*
0	66.69	65.12	70.28	57.49	61.02
1	68.09	66.59	71.31	59.83	62.93
5	64.57	63.07	67.75	56.57	59.58
10	59.83	58.35	62.96	51.88	54.83
15	55.06	53.61	58.13	47.21	50.11
20	50.40	48.98	53.36	42.76	45.68
25	45.85	44.44	48.66	38.62	41.56
30	41.29	39.87	43.97	34.61	37.44
35	36.78	53.34	39.33	30.65	33.37
40	32.38	30.91	34.79	27.00	29.65
45	28.13	26.66	30.34	23.44	25.96
50	24.11	22.67	26.04	20.36	22.76
55	20.35	19.02	21.95	17.68	19.71
60	16.82	15.64	18.05	15.17	16.94
65	13.64	12.65	14.48	12.74	14.59
70	10.85	10.03	11.31	10.64	12.53
75	8.38	7.72	8.58	8.64	10.46

Source: National Office of Vital Statistics, Release dated July 26, 1948. Metropolitan Life Insurance Co. *Statistical Bulletin,* v. 29, no. 11, November 1948.

creased to 1,650,000.[7] The increased construction and utilization of hospitals came about as a result of much greater urbanization of population and improvement in methods of diagnosis and treatment of illnesses which required more apparatus and instruments than the physician could afford to provide for his private practice.

Urbanization of Population; Health Problems Involved: The shift of population from rural areas to cities from 1840 to 1940 was quite marked. (See Table III.) At first the rapid growth of cities caused distinctly difficult health problems. Congested areas and slums developed, mortality rates increased, and epidemics of communicable diseases were common. Even today the urban death rate is slightly higher than the rural death rate. Various cities attempted to meet this problem by the establishment of boards of health. (See Chapter 16.) Increase in hospital facilities, installation of water purification plants, adoption of sanitary codes, especially applied to new construction of buildings, provision for waste disposal and many other activities contributed to the reduction of morbidity and mortality rates in cities. P. M Compulsory vaccination laws for school attendance caused smallpox to be greatly reduced in incidence. Later, the urging, sometimes requiring, of diphtheria immunization of small children by the schools and boards of health resulted in the almost complete disappearance of that disease from certain large communities.

The overcrowding of cities is still a major social and health problem which requires continuous vigilance on the part of health workers to prevent outbreaks of epidemics. It is claimed by Dr. Abel Wolman that there is hardly a city in the United States in which conditions of housing are not essentially worse than they were 100 years ago.[8]

The growth of cities and their comparative wealth caused greater activities on the part of both official and voluntary health organizations. The latter expanded with the growth of cities and such organizations as the Red Cross, the National Tuberculosis Association, the P. H American Social Hygiene Association, besides being national in character, established local societies in the larger cities and towns throughout the country. Such organizations as the American Public Health Association, the American Society for the Control of Cancer, the Na-

[7] Corwin, E. H. L. *The American Hospital,* p. 9. New York, The Commonwealth Fund, 1946.

[8] Reported in *Time,* Nov. 22, 1948.

TABLE III

URBAN AND RURAL POPULATION FOR THE UNITED STATES, 1840 TO 1940.

Census Year	*Population (in millions)*			*Per cent*	
	U. S.	*Urban*	*Rural*	*Urban*	*Rural*
1840	17.1	1.8	15.2	10.8	89.2
1850	23.2	3.5	19.6	15.3	84.7
1860	31.4	6.2	25.2	19.8	80.2
1870	38.6	9.9	28.7	25.7	74.3
1880	50.2	14.1	36.0	28.2	71.8
1890	62.9	22.1	40.8	35.1	64.9
1900	76.0	30.2	45.8	39.7	60.3
1910	92.0	42.0	50.0	45.7	54.3
1920	105.7	54.2	51.6	51.2	48.8
1930	122.8	69.0	53.8	56.2	43.8
1940	131.7	74.4	57.3	56.5	43.5

Note: Discrepancies in the above table are due to the rounding of numbers.
SOURCE: U. S. Department of Commerce, Bureau of the Census, *16th Census of the United States, Characteristics of the Population.* U. S. Summary, Washington, D. C., Government Printing Office, 1943.

tional Safety Council, the National Committee for Mental Hygiene, and many others supplied publications for the dissemination of health information. The American Medical Association developed cohesive and co-operative medical organizations in all the states and most of the counties of the country. These organizations concerned themselves with improvement and standardization of medical service, and later, with the spreading of information concerning health and disease. Business organizations, such as the National Dairy Council, began to educate the public, through advertising, concerning the health aspects of their products. Insurance companies had an interest in longevity and put out information on the control of disease and the promotion of health. Luncheon clubs of business men, such as the Rotary and Kiwanis clubs, developed an interest in crippled children, school lunches, and other community campaigns. Parent-Teacher associations, among other activities, soon showed definite health interests.

One of the outstanding characteristics of cities, as they developed, was their excessively high infant mortality rates. This gave health officers great concern as most of the deaths were from communicable

diseases. The growth of the speciality of pediatrics under the able leadership of Dr. Luther Emmett Holt of New York City, whose book *The Care and Feeding of Children* (New York, 1894) became an American classic and performed great service to the people of cities in helping to reduce these excessively high infant mortality rates.

Not the least of all health accomplishments was the technological developments since 1900. Such developments made possible the further growth and expansion of the population of cities. The first of these was the tin can for the preservation of food. Also glass jars were developed for the same purpose. Public transportation improved to such an extent that fresh vegetables could be shipped to cities within but a few hours after they had been picked. Refrigerator cars preserved meat and other foods for a limited time and made unnecessary the excessive salting and pickling of such foods. The invention and gradual improvement of cold storage facilities greatly benefited towns and cities and caused the people of the United States to be the best fed people in the world. The most important technological development was the pasteurization of milk and other liquid foods.

However, the technological developments have also been accompanied by some serious problems in health. One in particular is accidents which today is one of the leading causes of death. This is especially true in the field of transportation. The number of people injured, crippled, and killed by motor vehicles, for example, is alarming and causes great concern not only to health workers but also to the general public. This problem deserves special consideration and will be more fully discussed in Chapter 15.

Present Health Status of the Nation: War conditions of the decade 1939-48 make difficult the evaluation of health conditions in the United States as compared with other nations. In 1938, the last prewar year, statistics available seem to indicate, in a general way only, that the United States outranked all other large nations in low death rates. (See Table IV.) However, it is only proper to point out that some authorities disagree with the idea that comparison of crude death rates of various countries gives an accurate index of the health of the people of these countries.[9]

[9] This and many other problems concerned with health improvement is considered in *Medicine and the Changing Order.* Report of the New York Academy

TABLE IV

CRUDE DEATH RATES OF CERTAIN COUNTRIES WHERE SUCH STATISTICS ARE AVAILABLE, 1938

Country	*Death Rates per 1000 Population*
1. Dominican Republic	8.3
2. Netherlands	8.5
3. Canada	9.5
4. Union of South Africa	9.5
5. Australia	9.6
6. New Zealand	9.7
7. Norway	10.0
8. Uruguay	10.2
9. Denmark	10.3
10. United States	10.6
11. Sweden	11.5
12. England and Wales	11.6
13. Switzerland	11.6
14. Germany	11.7
15. Argentina	12.2
16. Scotland	12.6
17. Belgium	13.1
18. Eire	13.6
19. Bulgaria	13.7
20. Northern Ireland	13.7
21. Italy	14.0
22. Peru	14.1
23. Austria	14.1
24. Hungary	14.4
25. France	15.4
26. Portugal and Islands	15.5
27. Jamaica	16.3
28. Spain	16.5
29. Costa Rica	16.7
30. Colombia	17.3
31. Japan	17.4
32. El Salvador	18.1
33. Venezuela	18.7
34. Rumania	19.2
35. Guatemala	19.5
36. Ceylon	21.0
37. Mexico	23.1
38. Chile	24.6
39. British Guiana	25.8
40. Egypt	26.4

SOURCE: "A Review of Vital Statistics," *Vital Statistics, Special Reports.* Bureau of the Census, Washington, v. 17, no. 29, p. 535, 1943.

TABLE V

DEFECTS FOUND IN SELECTIVE SERVICE REGISTRANTS
April 1942 through December 1943
(Not necessarily causing rejection)

Rates per thousand men examined

EYE DEFECTS	136.1
Defective vision	90.7
Blindness, one eye	7.5
Total blindness	0.4
Other diseases of the eyes	37.5
EAR DEFECTS	35.1
Otitis media	13.6
Defective hearing	7.4
Deaf, one ear	1.2
Total deafness	0.6
Other diseases of the ear	12.3
DENTAL DEFECTS	113.0
Missing teeth	53.1
Dentures	36.2
Caries	18.0
Other dental defects	5.7
MOUTH AND GUM DEFECTS	14.5
DEFECTS OF THE NOSE	25.8
Nasal obstruction	15.2
Vasomotor rhinitis	5.0
Paranasal sinusitis	2.7
Other diseases and deformities of the nose	2.9
TUBERCULOSIS, ALL FORMS	19.1
Active pulmonary tuberculosis	6.7
Arrested pulmonary tuberculosis	6.1
Suspected or unspecified tuberculosis	5.4
Other tuberculosis	0.9
CARDIOVASCULAR DISEASES	51.0
Arterial hypertension	18.4
Valvular heart disease	12.9
Tachycardia	4.5
Rheumatic heart disease	3.6
Functional murmurs	3.6
Cardiac disease other than rheumatic or valvular	2.4
Cardiac hypertrophy	1.8
Cardiac arrhythmia	0.6
Other cardiovascular defects	3.2
DISEASES OF THE BLOOD OR BLOOD FORMING ORGANS	0.6
HERNIA AND RELAXED INGUINAL RINGS	50.2
Inguinal hernia	35.0
Relaxed inguinal rings	7.7
Abdominal hernia	3.9
Other & unspecified hernia	3.6
KIDNEYS AND URINARY SYSTEM	11.5
Laboratory urinary findings	6.8
Kidney stones, cystitis, etc.	2.7
Nephritis & pyelonephritis	2.0
DISEASES OF THE ABDOMINAL VISCERA	11.0
Gastric ulcer	5.8
Other gastrointestinal defect	5.2

TABLE V (*Continued*)

DEFECTS OF THE GENITALIA	33.7
Varicocele	15.5
Undescended testicle	4.5
Absence or atrophy of testicle	3.5
Other defects of the genitalia	10.2
SYPHILIS	50.2
Positive serology (latent syphilis)	32.4
Neurosyphilis	1.8
Cardiovascular syphilis	0.2
Other syphilis	15.8
FLAT FEET AND OTHER FOOT DEFECTS	54.6
SKIN DISEASES	14.0
EDUCATIONAL AND MENTAL DEFICIENCY	50.7
Educational deficiency	31.5
Mental deficiency, unspecified	13.0
Moron, imbecile, and idiot	6.2
MENTAL DISEASES	67.5
Psychoneuroses	37.0
Psychopathic personality	18.2
Grave mental or personality disorders	5.6
Chronic inebriety and drug addiction	4.0
Major abnormalities of mood	1.2
Mental disease not classified	1.5
NEUROLOGICAL CONDITIONS	28.0
Residuals of poliomyelitis	6.1
Epilepsy	5.1
Post-traumatic cerebral syndrome	3.9
Chronic encephalitic syndrome	1.0
Other neurological defects	11.9
MUSCULOSKELETAL DEFECTS	86.1
Residuals of injury	26.0
Amputations	10.2
Spinal malformations	10.0
Arthritis	4.8
Osteomyelitis	3.7
Ankylosis	3.3
Atrophy	3.0
Congenital and other musculoskeletal defects	25.1
OTHER VENEREAL DISEASES	6.3
Gonococcus Infection	5.9
Other venereal diseases	0.4
HEMORRHOIDS AND OTHER RECTAL DEFECTS	11.3
VARICOSE VEINS	16.2
ENDOCRINE DISTURBANCES	8.6
Diabetes mellitus	2.6
Froehlich's syndrome	2.5
Disturbances of the thyroid	2.1
Other endocrine disturbances	1.4
NEOPLASMS (Benign and malignant growths)	9.4
INFECTIONS (Parasitic and epidemic diseases)	0.6
OTHER DISEASES DEFECTS, AND ANOMALIES	72.5
Overweight	44.4
Underweight	21.1
Overheight	0.1
Other diseases and defects including nutritional disturbances	6.9

SOURCE: *Medical Statistics Bulletin No. 3,* National Headquarters, Selective Service, Washington D. C.

All of the countries which showed a better crude death rate than the United States in 1938 were small, and most of them have homogeneous, well-regulated populations. Of the major nations of the world the United States stood first, if judged by its crude death rate.

Certain disquieting facts have been brought out by the operation of Selective Service in the two World Wars. In World War I, 29 per cent of men drafted were rejected; an additional 26 per cent were found to have physical defects but were accepted. In World War II, 33 per cent of the men drafted were rejected [10] for physical defects. This did not mean that physical defects were on the increase in this country but that more careful examinations were performed. For example, the following procedures were adopted in World War II and neglected in World War I: (1) a psychiatric examination was performed; (2) psychological tests were given and those showing mental or educational deficiency were rejected; (3) tests for latent syphilis were made and those showing positive blood serology were not accepted; (4) chest X-rays were performed; (5) careful examination by various specialists revealed more defects than the examination by the general physician.

In spite of all the shortcomings of the Selective Service in World War II, a fairly accurate picture of the general health status of men in this country was obtained. There are many difficulties in the way of correct appraisal but by utilizing the data so far released (1948) certain definite lessons may be learned. The most accurate picture is obtained from a study of the earlier bulletins published during the war.[11] The ten leading causes for rejection from April 1942 to March 1943 were mental disease (12.5 per cent of rejections), educational and mental deficiency (10.7), syphilis (9.4), musculoskeletal defects (9.3), cardiovascular diseases (8.8), diseases and defects of the eyes (7.8), hernia (7.8), neurological conditions (5.5), diseases and defects of the ears (5.0), and

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of Medicine, Committee on Medicine and the Changing Order. New York, The Commonwealth Fund, 1947.

[10] 14,484,000 men examined, 4,828,000 rejected.

[11] Especially Medical Statistics Bulletin No. 3. *Physical Examination of Selective Service Registrants During Wartime.* An Analysis of Reports for the Continental United States, April 1942 through December 1943. National Headquarters, Selective Service System, Washington, D. C., Nov. 1, 1944.

tuberculosis (4.1).[12] The older the individual examined the more physical defects were found.

Among the figures obtained the most startling ones concerned the great prevalence of mental disease, mental and educational deficiency, and syphilis (See Table V). The geographical distribution of significant rejection rates is illustrated in Figs. 6, 7, 8, 9, 10, 11 and 41. The others showed fairly even distribution over the United States and are not illustrated in graphic form. The rather high incidence of common physical defects were not surprising to those doing large numbers of physical examinations in colleges and in industry. In comparing various defects in certain areas only general impressions can be made as induction centers varied greatly in their policies. The data for figures mentioned above were obtained from sampling and not from the whole group.

Wide differences in health status exist as revealed by Selective Service figures. These differences indicated that the population was heterogeneous and presented different deficiencies in the various regions of the country.

Health surveys are of paramount importance in presenting to the people the facts which could lead to correction. At least they point the way to professional health workers by indicating which are the major health problems for the individual and the community.

Recent Medical Discoveries: As the agents of disease were discovered, methods of prevention of some soon followed. In subsequent chapters certain details of principal factors in disease prevention will be discussed. The student will notice that great variation exists in the specific prevention of many diseases. Improvement in environment is usually followed by a decrease in incidence of certain conditions. Filtration and chlorination of a contaminated water supply leads to a marked reduction in most intestinal diseases. (See Fig. 56.) Pasteuriza-

[12] Statistics for World War I were not classified in exactly the same manner as those for World War II, hence direct comparisons are not possible. The percentages of total rejections in World War I for various conditions were as follows: Miscellaneous mechanical defects 18.0 per cent, weak feet 12.0, defects of the sense organs 12.0, diseases of the heart and arteries 10.0, defects of development and metabolic processes 10.0, nervous and mental disorders 6.0, syphilis, gonorrhea and chancroid 5.8, tuberculosis 5.4, defective or injured fingers and toes 5.0, defects of the nose and throat 5.0, hernia 4.0, defects of skin and teeth 3.0, respiratory diseases (except tuberculosis) 1.0, other defects and disorders 2.8.

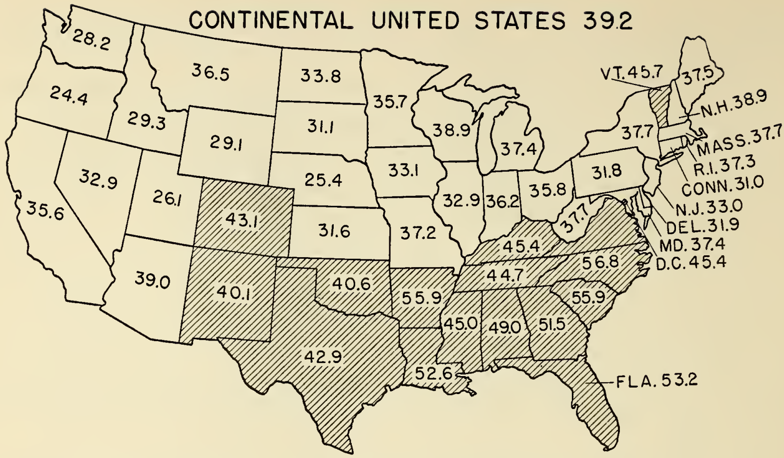


FIG. 6. Rejection Rates for All Causes per 100 Registrants Examined. Selective Service, February 1942 through August 1943. (States in the shaded areas showed more than average incidence.)

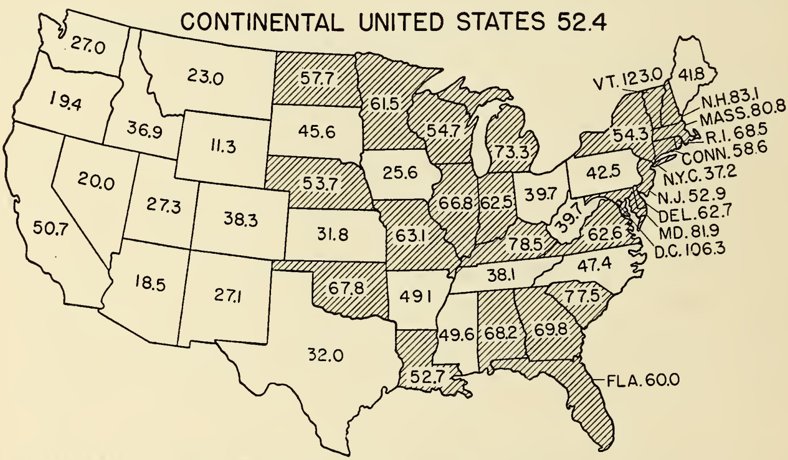


FIG. 7. Rejection Rates for Mental Diseases per 1,000 White Registrants Examined, April 1942 to March 1943. (States in the shaded areas showed more than average incidence.)

Data from *Medical Statistics Bulletin No. 3,* National Headquarters, Selective Service System, Washington, D.C.

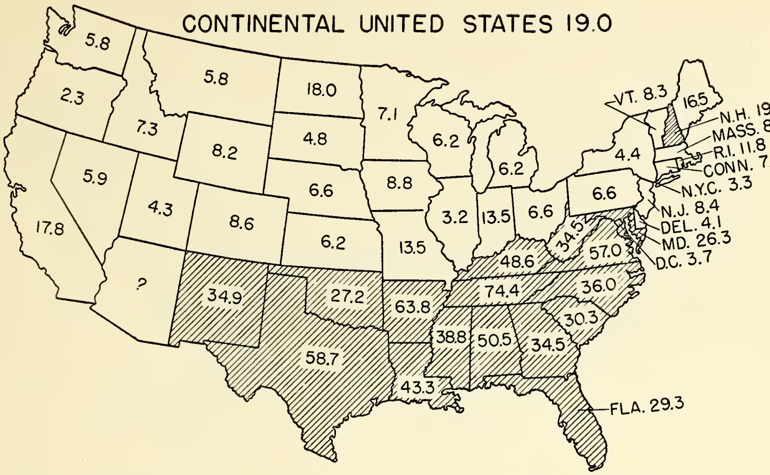


FIG. 8. Rejection Rates for Educational Deficiency per 1,000 White Registrants Examined, April 1942 to March 1943. (States in the shaded areas showed more than average incidence.)

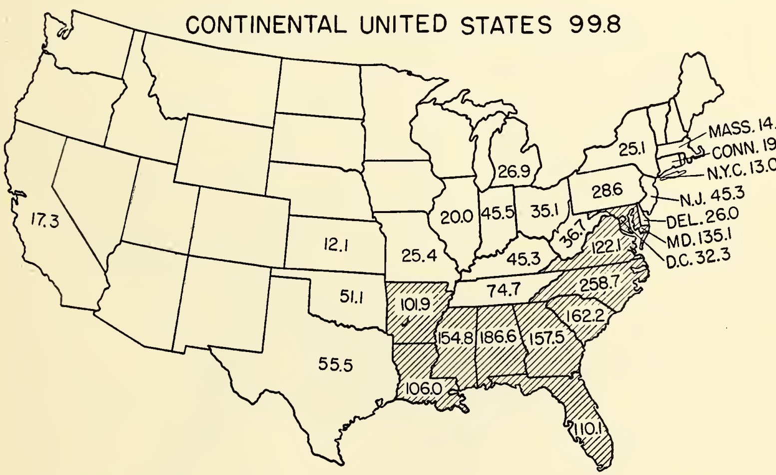


FIG. 9. Rejection Rates for Educational Deficiency per 1,000 Negro Registrants Examined, April 1942 to March 1943. (States in the shaded area showed more than average incidence.)

Data from *Medical Statistics Bulletin No. 3,* National Headquarters, Selective Service System, Washington, D.C.

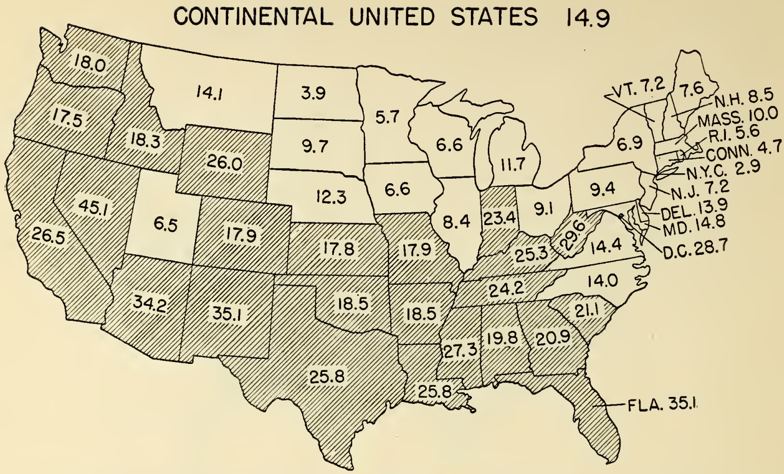


Fig. 10. Rejection Rates for Syphilis per 1,000 White Registrants Examined, April 1942 to March 1943. (States in the shaded areas showed more than average incidence.)

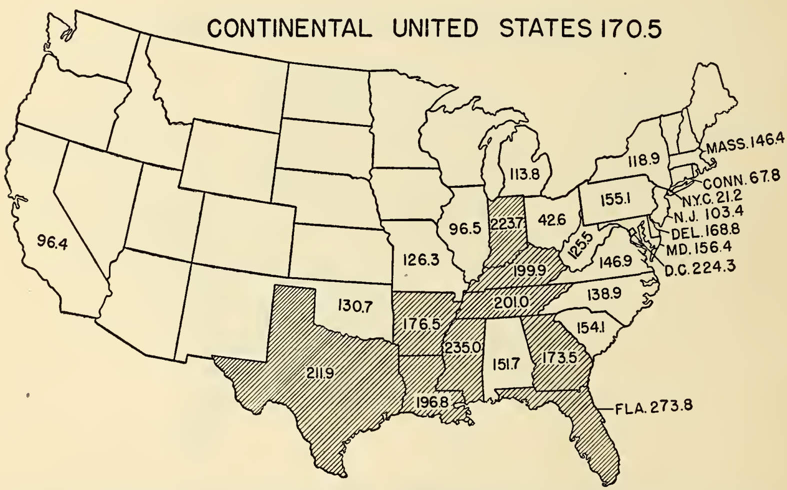


Fig. 11. Rejection Rates for Syphilis per 1,000 Negro Registrants Examined, April 1942 to March 1943. (States in the shaded areas showed more than average incidence.)

Data from *Medical Statistics Bulletin No. 3,* National Headquarters, Selective Service System, Washington, D.C.

tion of milk leads to a diminution of gastroenteritis in children. (See Fig. 77.) It also leads to a reduced amount of bovine tuberculosis once so common in cattle. (See Fig. 62.) Indeed, if it were not for rather extensive pasteurization of milk, undulant fever would be much more prevalent than it is, for brucellosis is common in cattle. (See Fig. 63.) Specific immunization has reduced smallpox and diphtheria to low levels. (See Fig. 32.) This practice has helped eliminate typhoid fever as a major military disease. Other well recognized preventive measures, applied sometimes half-heartedly, have often resulted in a greater proportionate reduction of certain conditions than workers thought possible.

Recent medical discoveries have played an important role, especially in the case fatality rates.[13] The most important of these discoveries began with the discovery of chemotherapy and was extended by the discovery of antibiotics. Paul Ehrlich in 1910 discovered that salvarsan, a complex compound of arsenic and other elements, could be introduced by intravenous injection into man without killing him but would destroy the microbe of syphilis. This was a very important discovery because syphilis, a common endemic disease, had caused many deaths since it was first accurately described by Fracastor in 1530. Before the advent of salvarsan, treatment consisted in rubbing mercury into the skin (mercury inunctions) and the taking of mercury salts and potassium iodide by mouth. The older remedies were but feeble and by no means cured the disease in even a significant number of cases. Mercury salts by mouth were dangerous and led to certain kidney complications. After the discovery of salvarsan by Ehrlich, others tried various substances in other diseases without much success and the progress of chemotherapy seemed to slow up. Certain substances (quinine, plasmoquin, atabrine, etc.) were effective against malaria, but until the advent of the sulfonamide compounds there had been no chemotherapeutic substances of note discovered.

The "sulfa" drugs, as they are now called popularly, were the outcome of research work on the aniline dyes, which began in the middle of the nineteenth century and progressed until the present. One of the substances derived from the dyes, prontosil, was selected as not as toxic as others and its compounds were studied in detail. The result was the

[13] Case fatality rates are explained in Chapter 17.

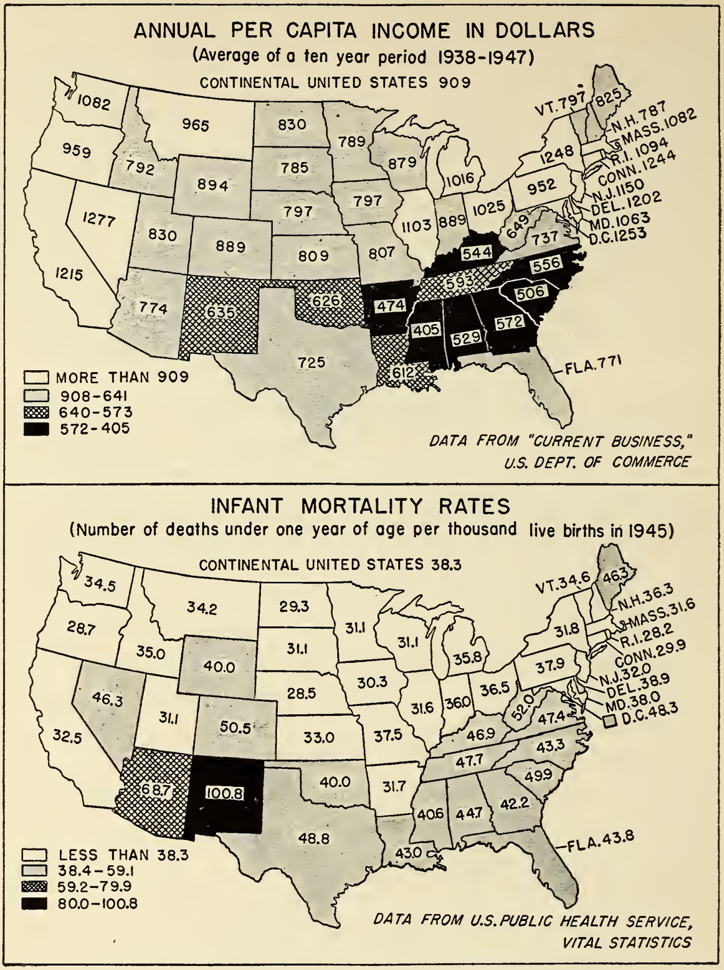
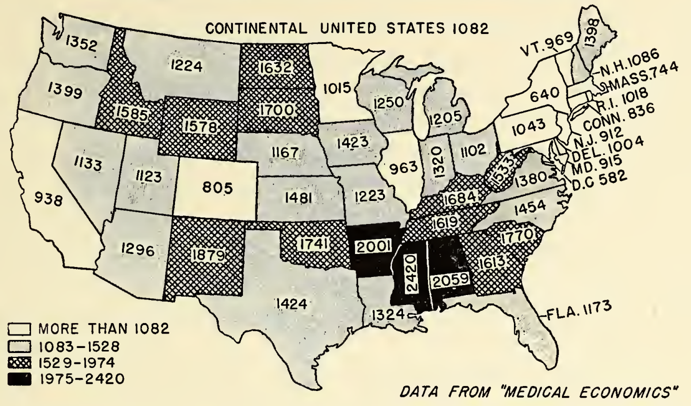


Fig. 12. Theoretically there should be a correlation between income, private medical care, education and health. The maps above contain data on each of these subjects. The white areas indicate favorable situations while the shaded to black areas indicate unfavorable ones. Infant mortality rates are chosen in the health field because they are considered to be a delicate measure of the health status of a community; they are specific rates and usually indicate the quality and quantity of medical care and the general health practices of the people.

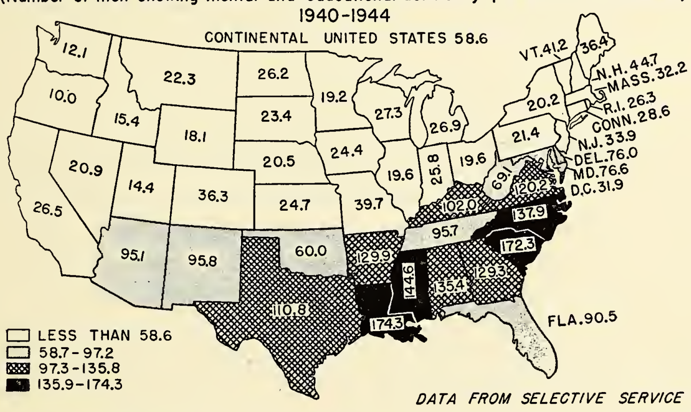
The area of high infant mortality rates is more restricted than areas of low income and lack of medical care. The area of high mental and educational deficiency is the most restricted of the four.

There are several factors worthy of note: The states Utah and Idaho have low per capita income rates, less than average distribution of private medical care but low infant mortality rates and high educational attain-

DISTRIBUTION OF MEDICAL CARE
(Number of inhabitants per active private physician in 1948)



MENTAL AND EDUCATIONAL DEFICIENCY IN WORLD WAR II
(Number of men showing mental and educational deficiency per thousand examined)
1940-1944



ment in comparison with many other states. To a slightly lesser extent the same is true of several other states.

Only a small minority of states show a favorable situation while a larger number presents an unfavorable picture in all four of the above mentioned factors.

Maryland and Minnesota, being medical centers, are abundantly supplied with physicians and have relatively low infant mortality rates.

Arkansas is an enigma; its people lack income, medical and educational advantages yet it has a low infant mortality rate and is unique among all states so situated. Delaware and the District of Columbia have high infant mortality rates. Colorado, in spite of better than average educational status and medical care, shows a high infant mortality rate possibly because of a difficult terrain.

Data for Distribution of Medical Care reprinted by special permission from *Medical Economics* (Copyright 1948.)

successive development of sulfanilimide, sulfapiridine, sulfathiozole, sulfadiazine, sulfaguanidine, and others. Other sulfa compounds are under investigation at the present time. The sulfa drugs are not without hazard; they have to be used with care, and laboratory controls are needed when they are administered. They have a tendency to crystallize in the kidney tubules thus causing severe pain and dangerous blocking of excretion. They also tend to accumulate in the blood of some individuals, who do not excrete them normally, and produce a toxic condition in the patient. These eventualities are discovered by laboratory tests on the blood and urine. The layman is warned that they cannot be used by him with safety except under the supervision of a physician.

The action of the sulfa drugs is interesting in that they aid the natural resistance to disease discussed in Chapter 4. They do not kill the microbes infecting the patient by direct chemical action but act in such a way as to prevent them from obtaining the substances they need from their hosts. This prevents their multiplication and gives the phagocytes a chance to destroy them.

The antibiotics were developed just prior to World War II and had extensive clinical tests during that period. In 1929 Sir Andrew Fleming, a British physician, reported that a common green mold secreted a substance, which he called penicillin, that was antangonistic to and inhibited the growth of staphylococci growing on culture media in his laboratory. (See Figs. 16 and 17.) Fleming's work was extended by Florey, an Australian physician in 1941. Purification and standardization were carried on in the United States until the commercial product now has a high degree of efficacy. It is fairly safe and has been quite effective in the treatment of many (but by no means all) infectious diseases. It is often used in combination with various sulfa drugs.

Streptomycin, discovered by Waksman and Schatz in 1944, is being used to treat certain diseases such as tuberculosis and tularemia which are not influenced by sulfa drugs or penicillin. This substance was named after the mold from which it was derived.[14]

Other antibiotic substances are being investigated to combat diseases not now influenced by chemotherapy and antibiotics in common use. Aureomycin, for example, has proved to be remarkably efficacious in

[14] Waksman, S. A. *Microbal Antagonisms and Antibiotic Substances.* New York, The Commonwealth Fund, 1945.

the treatment of virus pneumonias.[15] Other antibiotics, now under investigation (1949), are chloromycetin, bacitracin, gramicidin, tyrothricin, neomycin, and others.

Antibiotics and chemotherapeutic substances were, at first, thought to be effective as prophylactic agents to prevent diseases as well as therapeutic agents to cure them. Unfortunately the results have been disappointing because certain strains of various forms of bacteria develop a resistance to these substances and remain viable in the patient treated by them. It is feared that the widespread use of chemotherapy and antibiotics in prophylaxis and mild illnesses may result in the presence of a large number of sulfa-resistant and antibiotic-resistant microbes in man's environment, an unsatisfactory or even dangerous situation. Should all organisms and viruses become resistant to antibiotics and chemotherapy these substances would become useless in the treatment of disease. Herein lies another danger in the promiscuous and general use of drugs in conditions which are mild and usually respond to other forms of treatment. Their use should be very selective, even by the physician.

Probable Health Activities of the Future: In the past public health or community health activities have concerned themselves largely with the control of communicable diseases. Such activity will continue in the future for the price of safety is eternal vigilance. The control of the environment to make it relatively safe has been fairly successful. More effort is needed to make it still better. Added to this endeavor, and more difficult to attain, is the improvement of individual resistance in an effort to escape microbes that may find their way through the barriers in the environment. It remains for the future to develop also some form of daily routine for the individual to follow which will help him overcome or minimize the hazards of degeneration within himself. The last is a much more complex problem which will tax the ingenuity of man to find out the causes of degeneration and possible remedies.

Developing individual resistance to disease is only partly successful because protective inoculations or immunizations are available for only a relatively few diseases such as smallpox, diphtheria, typhoid

[15] Schoenbach, E. B. and Bryer, M. S. "Treatment of Primary Atypical Nonbacterial Pneumonia with Aureomycin." *Journal of the American Medical Association*, v. 139, p. 275, January 29, 1949.

fever, Asiatic cholera, plague, yellow fever, whooping cough, rabies, and a few others. Developing individual general resistance to infections is possible but very uncertain. It is well known that diseases of all kinds follow war, starvation, exposure, and other deleterious influences experienced by man. It is also well known that overwork, excessive fatigue, inebriety, and other common habits of man reduce his general resistance and invite infection. But more than this needs to be known before it will be possible to improve man's health situation of the moment.

Improvement in health as a result of the adoption of sound health habits in man was started at the end of the nineteenth century under the leadership of Dr. Luther Emmett Holt, mentioned above, and passed on to the pediatricians. The prevention of infections and dietary deficiency diseases led to a marked improvement in infant mortality. (See Fig. 103.) Not only did more infants survive the first year of life but children grew to be taller and heavier. The average height of men in ages 20-29, examined at the induction stations for the armed services in World War II in May, 1943 was 68.15 inches. This is about two-thirds of an inch more than the average 67.49 inches for the first million draftees of ages 21-30 examined at mobilization camps in 1917 for World War I.[16] Also, records in athletic contests are broken year by year; not many of them stand for long. Improvement in general health of children has thus been passed on to subsequent decades when such children became adults. The expectation of life has been increased in all decades.

The great health problem of the future will be concerned with the reduction of degenerative diseases such as arteriosclerosis, heart diseases, diabetes, nephritis, cancer, senile dementia, and other conditions taking a heavy toll of middle-aged people at the present time. We have every reason to believe that many of the so-called degenerative diseases may be postponed for some time. No doubt this postponement will depend a great deal on health education for as new truths are determined they must be applied through health instruction, health service, and other activities of those working in the health field. As one author puts it,

[16] Statisticians of the Metropolitan Life Insurance Company, "Increase of Stature of American Men." *Statistical Bulletin,* v. 25, no. 11, p. 1, November 1944.

That the health of well babies can be improved has been demonstrated convincingly by modern pediatric practice; guidance in nutrition, regulation of exercise, instruction in sane cleanliness, and advice regarding wiser habits of living do develop healthier children. It is absurd that such medical guidance should be applied only to infants and children. Adults are also entitled to an opportunity to improve their state of health.[17]

To keep human beings healthy and to prevent degenerative diseases is now, and probably always will be, the function of the private practioner of medicine. Co-operation toward this end is developing between public health workers and physicians. The objectives and modes of approach toward better health are outlined by Stieglitz on next page.[18]

[17] Stieglitz, E. J. *A Future for Preventive Medicine,* p. 4. New York, The Commonwealth Fund, 1945.

[18] *Ibid.,* p. 7. (This outline is reprinted by permission of the author and copyright owners, The Commonwealth Fund.)

1. OBJECTIVES
    1.1 *Prevention of disease*
        a. Non-specific protection
        b. Specific protection
    1.2 *Prevention of undue health depreciation by construction of greater health*

2. PRESENT MODES OF APPROACH
    2.1 *Control of environment (wholesale or indirect measures applied largely by public health and sanitary services)*
        2.11 Sanitation
            2.111 Sewage disposal
            2.112 Maintenance of purity in water supply
            2.113 Food inspection (including milk and meat and health of food handlers)
            2.114 Control of atmospheric contamination (industrial ventilation: removal of dusts, fumes, gases; smoke abatement)
        2.12 Control of animal vectors of disease
            2.121 Insect vectors: mosquitoes (malaria), fleas (plague), and lice (typhus fever)
            2.122 Mamalian vectors: cattle and meat (tuberculosis, actinomycosis, brucellosis, pigs and pork (trichinosis), rodents, (tularemia, plague, etc.), and dogs (rabies)
            2.123 Avain vectors (psittacosis)
        2.13 Control of human sources of infection: quarantine
            2.131 Laboratory services assisting rapid diagnosis of communicable diseases, prerequisite to prompt isolation
            2.132 Port quarantine and inspection (acute and chronic communicable diseases)
            2.133 Enforcement of local quarantine of communicable disease cases
            2.134 Enforcement of isolation or therapy of promiscuous carriers of veneral diseases
    2.2 *Individual protection*
        2.21 Immunization (against specific infective diseases)
        2.22 Prenatal medical care
        2.23 Nutrition guidance
            2.231 Public education
            2.232 Pediatric management (rickets, scurvy)
        2.24 Education in hygiene
        2.25 Safety devices individually utilized (goggles, masks, protective clothing, etc.)

Many of the topics in the above outline will be discussed in the pages which follow.

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3

TYPES AND CAUSES OF DISEASE

Classification of Diseases: The human body is subject to a great variety of impairments in health. In many cases the causes and nature of the condition are not known and for that reason any attempt to classify disease is fraught with certain difficulties. A simple classification may be used as a basis for the discussion that follows in this chapter.

1. Specific Infectious Disease. The affection may be general and involve the entire body, such as influenza, or it may be local and confined, for the most part, to one particular area, such as a carious tooth. These conditions are caused by living (animate) organisms. The causative agents include the bacteria and fungi (molds, yeasts, and actinomycetes) in the plant kingdom, and protozoa and metazoa in the animal kingdom. Filtrable viruses are also included.

2. Hereditary Disease and Congenital Malformations. Some conditions, such as idopathic epilepsy, and hemophilia, are hereditary in nature. The most common congenital condition is a malformation of some kind.

3. Diseases of Metabolism. The cause in conditions such as scurvy is usually a deficiency or absence of some necessary food element. In other nutritional diseases, such as endemic goiter, a disturbance in some internal secretion may also be a factor.

4. Chemical Poisons and Intoxications. The disease and injury is caused by a long list of toxins and poisons from drugs, foods, gases, metals, and certain living creatures such as snakes and insects.

5. Injuries Due to Mechanical and Physical Factors. These conditions are caused by a great variety of agents such as falls, firearms, machinery, heat, cold, electricity, and many others.

6. Tumors, Especially Cancer. The cause of these is unknown.

7. The Puerperal State. Although this is a normal state it is sometimes accompanied by impairment in health or death to the mother or child or both.

8. Ill-defined and Unclassified Diseases. There are a number

of conditions, such as chronic constipation, which do not fall under any of the above headings.

Diseases caused by minute organisms are often contagious but the degree of contagiousness varies greatly. Some diseases caused by bacteria are not contagious, *e.g.,* tetanus or lockjaw. Most infectious diseases are general in character, *i.e.,* several of the tissues of the body are invaded by the bacteria or toxins. Some diseases, however, remain quite local. On the whole we may assume that if a disease is accompanied by fever it is a general disease.

One should think of a disease in terms of its cause, for any control must be directed at the cause. If the cause is not known we are usually unable to cope with the disease, either by way of prevention or treatment. A striking example of this lies in the cancer problem; the incidence of cancer increases, and its death rate constantly mounts. It is quite apparent that all diseases are not of bacterial, physical, chemical, or mechanical origin. Fully half of all disease is caused by inherent weakness in the organism; the exact nature of this weakness remains unknown or is only imperfectly understood. At the present time diseases of degeneration are taking a greater toll of human life than ever before while contagious disease is on the decrease.

Theory of Disease: Hippocrates, the famous Greek physician (460 B.C. ?—357 B.C. ?) was the first to attempt an explanation of disease on an internal basis. His idea of the "humors" of the body and their relation to disease influenced the thought of mankind for about two thousand years. Our word "humor," of course, is the same word, indicating that when the individual felt well and happy he was in humor, and out of humor when the opposite was true. In a word, his idea was that the body was composed of four humors or fluids: blood, phlegm, yellow bile, and black bile, and that these fluids were responsible for health and disease. He thought that the weather profoundly influenced these humors so that a disproportion would often result. If the black bile predominated the melancholy humor therefore prevailed. The patient was cold and dry in such a case, his condition corresponding to the autumn. The phlegm corresponded to the winter, the blood to the spring, and the yellow bile to the summer. In spite of the incorrectness of the theory, it was a great advance over the demonic theory of disease, in which disease was pictured as a visita-

tion of an offended god or a demon, or in the Christian religion, as the work of the devil.

The Jewish laws set forth in the Talmud during the second to the sixth centuries A.D. spoke of the existence of microbes. The Talmud states that infectious and contagious diseases are brought on by "little dangerous ones" that are passed on to healthy people from the sick. Because of this, the law forbade spitting on the streets in Jerusalem, drinking unboiled water, and eating food flies had contaminated, as they were called carriers of disease.

Theories other than the germ theory made their appearance from time to time, but did not greatly influence medical thought until the pythogenic theory of the early nineteenth century. This theory is mentioned here because some people still believe it to be true. The pythogenic theory holds that disease is produced by filth or putrefaction of animal or vegetable matter. From an esthetic point of view, it is well that people believe as they do, but it is unfortunate if such a belief leads them to a false sense of security in cleanliness alone.

The present day theory of infectious disease is the germ theory, the beginning of which is obscure. Contagion had been noticed for a long time. Philosophical writings were filled with vague theories as to the actual causes of the contagiousness of certain disease. Either rightly or wrongly, scientists have considered the microscopist, Anton van Leeuwenhoek, a pioneer in the theory of the microbic origin of disease. He was the son of a prosperous basket maker in Delft, Holland, but had little education except of a very elementary kind. He was primarily a business man, and the caretaker of the City Hall. Lens grinding, which ultimately made him famous and immortal, was an avocation with him. So skillful did he become with his lenses (which numbered some 400, together with about 250 microscopes) that he was able to develop a "sixth sense," and see things that the rest of the world could not see. He began to examine everything he could find. In looking at rain water one day he discovered very remarkable microscopic animals and plants swimming about. In fresh rain water however, there was no microscopic organisms. He noticed that bits of food removed from between his teeth, were alive with tiny creatures. He examined alvine discharges in diarrhea, and noticed microbes in great profusion. He discovered that heat killed them, and he did everything but actually ascribe to them the causes of disease. This work was

begun around 1660 and for about 200 years was forgotten. It may be safely said that the nature of disease was not understood at all until Rudolf Virchow published his famous book *Cellular Pathology* in 1858. This was the first exhaustive description of the effect of disease upon the structure of the body. He described the changes occurring in inflammation, which is the common reaction of the body tissues to the insult of bacteria or other agents. The improved microscope as we have it today did not make its appearance until about 1835 and the oil-immersion lens microscope, which completed the ocular laboratory equipment and made possible the development of bacteriology, was invented by Ernst Abbé in 1886. In 1837 the Italian, Agostino Bassi, discovered that *muscardine,* a disease of silk worms, was caused by a parasitic fungus (*Botrytis bassiana*), and in 1839 the German, Johann Lukas Schoenlein, discovered that honeycomb ringworm of the scalp, a contagious disease, was caused by a parasitic fungus (*Achorion schoenleinii*). So far as is generally known these were the first proven diseases caused by living parasites.

Fermentation gave one of the earliest clues to the nature of microbic action in disease. To whom should go the honor of the discovery of the exact mechanism in fermentation is in some dispute. Cagnaird de Latour, Theodor Schwann, and Louis Pasteur seem to have contributed to or developed it. As strange as it may seem infectious disease is often analogous to fermentation.

A FERMENTATION (Apple juice)	AN INFECTIOUS DISEASE (Smallpox)
1. Exposure of the juice to air, dust, etc.	1. Exposure of the patient to infection.
2. Repose and then slow change. (Growth of the ferment.)	2. Incubation. (Slow and insidious progress of the disease.)
3. Active fermentation or "working." Evolution of gas bubbles, change of sugar to alcohol. Rise of temperature or "heating."	3. Active disease. Eruption, disturbance of the usual functions. Rise of temperature or fever.
4. Gradual cessation of fermentation.	4. Slow convalescene (or death.)
5. No further liability to alcoholic fermentation.	5. Immunity to smallpox.

Pollender in 1849 and Casimir Davaine in 1850 found the anthrax bacillus in the blood of animals dying from that disease. In 1850

Davaine injected anthrax germs into a healthy animal and caused its death. He was thus the first person (known) to inoculate a healthy animal with a germ he could see under the microscope, and produce a well-known epidemic disease of cattle.

FIG. 13. ANTON VAN LEEUWENHOEK 1632–1723

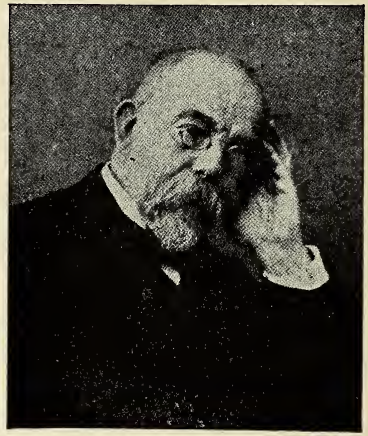


FIG. 14. ROBERT KOCH 1843–1910

These experiments and others led Robert Koch, the famous German bacteriologist, to lay down his four postulates in 1878, which have been a guide ever since in proving that a microbe is the cause of a particular disease. The postulates of Koch are these:

1. The specific organism must always be associated with the disease.
2. It must be isolated in pure culture.
3. When inoculated into a healthy, susceptible animal, it must always produce the disease.
4. From an animal so infected it must again be obtained in pure culture.

Thus we may see that the theories of disease which stand at the present time have been of comparatively recent origin. It should be reiterated, in passing, that only about half of present-day diseases are of bacterial origin. The rest are hereditary or due to accidents, chemical injury and poisoning, inevitable degeneration of organs, senility, and those of unknown cause such as cancer.

Animate Agents and Disease: By far the most important diseases caused by animate agents are those caused by organisms of the simplest structure, minute plants (bacteria) and animals (protozoa). It is quite true that certain higher plants and animals also cause disease but such diseases are usually not very common, even though they are important. In addition, certain substances known as filtrable viruses and ultramicroscopic organisms, which will be discussed later, are responsible for many of our most prevalent diseases, among which are measles, smallpox, and chickenpox.

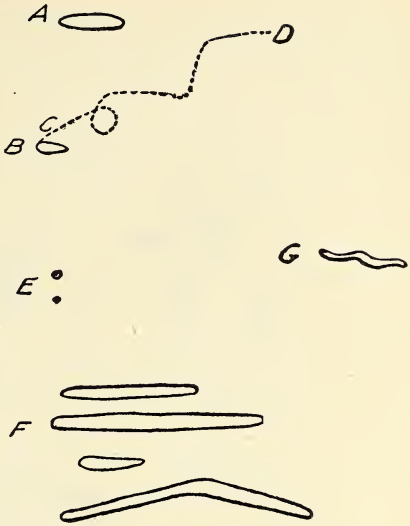


FIG. 15. Drawing of bacteria after Leeuwenhoek. The dotted line C to D indicates movement of bacteria.

From Greaves, *Elementary Bacteriology.* Copyright W. B. Saunders Co.

Bacteria: By definition these are minute (*microscopic*) single-celled vegetable organisms which multiply by tranverse division (*tranverse fission*). They are very small, not more than $\frac{1}{5000}$ of an inch in

FIG. 16. Culture dish showing colonies of bacteria and mode of transfer to other media.

John Koopman, "Smallest Farm in the World." Courtesy *Hygeia*

diameter while some are smaller than $\frac{1}{125000}$ of an inch. They have a widespread distribution, and can be found wherever life is at all possible. The upper layers of the soil teem with them, they are in abundance in fresh and salt water, they are present in air, and are not altogether killed in ice and snow. They cover our bodies and line some or our "outside" cavities—the nose, throat, stomach, and intestines. Most of them however only grow and multiply at a temperature range which other plants require.

On the basis of their shape bacteria have been divided into three general groups: the spherical form family (*Coccoceae*), rod-shaped bacteria (families *Bacteriaceae, Bacillaceae,* and *Mycobacteriaceae*) and spirals or segments of spirals (family *Spirochaetaceae*). Organisms may not necessarily be perfect spheres, rods, or spirals. Some spherical bacteria are elongated, some have flattened surfaces, and others have certain peculiarities which help in their identification. Rod-like bacteria may have rounded, pointed, or ball-like ends. Spheres which divide in one direction and remain attached are found in pairs (*Diplococci*), or in shorter or longer chains (*Streptococci*). Those which divide in two directions, one at right angles to the other, form groups of four (*Tetracocci*). Those which divide in three directions and cling together to form patches of cubes are called *Sarcinae,* and, finally, those which divide irregularly clinging together in grape-like form are called *Staphylococci.*

Bacteria do not have nuclei, as a rule, but they do contain nuclear material distributed throughout the cytoplasm. Their wall is rather rigid, but this quality varies considerably with different species, and explains why some simple bacteria are more resistant to unfavorable environment than others. Outside of the walls of some varieties there is a slimy sheath, called the *capsule.* Sometimes this capsule is of a waxy nature, as that which surrounds the *Mycobacterium tuberculosis,* and makes it a little more resistant to unfavorable environment than some others. Unlike other plants, bacteria are not green (they contain no *chlorophyl*) and many have the power of locomotion by reason of *flagella* attached at one or both ends or distributed over the organism.

Bacteria reproduce by transverse fission. The organism becomes constricted in the middle, and one cell divides into two daughter cells. The reproduction then is non-sexual, and occurs under ideal conditions about once every twenty or thirty minutes. If the number be

calculated mathematically, at the rate of one division every half hour for 24 hours, more than 140,000,000,000,000 descendants would result. Naturally all do not survive, but the multiplication is enormous, and

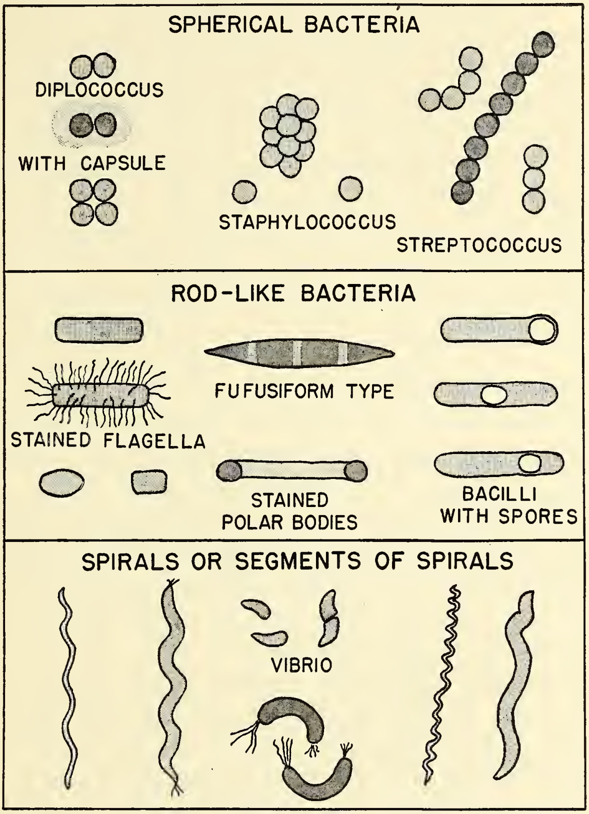


Fig. 17. The three basic shapes of bacteria.

one organism in a dish of proper media can become a colony apparent to the naked eye in a day.

Some bacteria form *spores,* which have nothing to do with reproduction, but which represent the resting stage of the organism (See Fig. 17). These spores are highly refractile bodies situated at various positions within the cell membrane. The protoplasm of the cell con-

tracts within the wall and forms a second, very resistant wall. In this stage the organism can be boiled without killing its spore, which can live almost indefinitely under a very unfavorable environment. When the conditions are right for its growth, it can develop into the full sized organism, and start a new cycle. This is of tremendous importance in such diseases as lockjaw (tetanus) and splenic fever (anthrax). All deep wounds contaminated with soil are liable to the former complication, and hides of cattle which have died of splenic fever are apt to transfer the disease to those who handle them later on.

Most bacteria require protein for food, and usually obtain it from the dead bodies of plants or animals, or from materials which have been made from plants or animals. These bacteria are spoken of as *saprophytes* or *saprophytic* bacteria. They are really beneficial to mankind, and do not produce disease. Some varieties manufacture cheese, produce buttermilk, make wine from fruit juices, cause the destruction and disappearance of the carcasses of animals. The names of these processes are familiar to everyone. The process involved in the destruction of carcasses of animals (or plants) is commonly called decay (putrefaction), and is produced by two general types of bacteria (*nitro*bacteria): those which, by a process of oxidation, change ammonia or compounds of ammonia into compounds of nitrous acid (the *nitrites*), and those which further oxidize the nitrites to nitrates. The nitrates formed in this way serve as a fertilizer for further and higher plant life. Thus a cycle is carried on in nature which is only made possible by the action of nitrobacteria.

More important from the standpoint of disease are the parasitic bacteria (*pathogenic* bacteria) which cannot thrive outside of the body of an animal (its *host*) or need solutions or media especially prepared for their growth. They obtain their protein from living animals or plants in contrast with the saprophytic bacteria mentioned above. After the host dies, in most cases, the bacteria die. Some bacteria are saprophytic at times and pathogenic at others and are spoken of as *facultative* bacteria. Most bacteria require oxygen for growth (*aërobic* bacteria) while for others oxygen is a poison (*anaërobic* bacteria). Some produce a specific chemical substance called a *toxin* for which in most cases an *antitoxin* may be manufactured as will be described later.

Bacteria which produce disease are the same as have always existed.

They do, however, become stronger or weaker, *i.e.,* they change in *virulence,* and different "strains" or families of bacteria become more virulent than others.

Fungi: An ever increasing number of fungi are found to be the causes of diseases. The following are the most common:

Pathogenic molds cause a group of diseases popularly spoken of as ringworm. These organisms attack the hair and the smooth skin. They produce athlete's foot, jock-strap itch, and other well-known infections.

Of the saprophytic molds, species of *Penicillium* secrete penicillin, an antibiotic substance extensively used in medicine.

Transitional forms between the molds and yeasts produce blastomycosis, a disease of the skin, and coccidioidomycosis, a disease found in the San Joaquin valley in California and known as desert fever.

Pathogenic yeasts produce the diseases thrush and sprue. Histoplasmosis, usually a benign disease of the lungs, is interesting in that it causes calcifications simulating tuberculosis.

Actinomycosis or "lumpy jaw" in cattle and man, is caused by one of the *Actinomycetes*.

Protozoa: These are the lowest forms of animal life, and are also very numerous in nature. Only a relatively small number produce disease. By definition they are single-celled animal micro-organisms which present a more or less complicated life cycle. Most of them contain nuclei, and are of a higher grade of life than bacteria, just as man is of a higher grade than a tree. No general description will fit them. In size some are as small as the smallest bacterium while the largest may be many times the size of a bacterium. They are usually actively motile, and have the power of nutrition, respiration, and reproduction. Many react to light either moving toward it or away from it. They absorb both liquid and solid food, and excrete wastes. They also excrete toxic substances in disease. They breathe through the cell wall, or possibly through a contracting vacuole.

Their methods of reproduction vary greatly. Some reproduce by transverse fission, like bacteria, others by longitudinal fission. Sometimes the division is simple (*amitotic*), other times more complicated (*mitotic*). Some varieties reproduce by budding as do the yeasts. In some there is a type of internal budding, so that many daughter organisms form within the parent cell. Sexual reprodutcion has been noticed in many types and in general we differentiate two kinds: (1) re-

production by copulation which is not dissimilar to fertilization of an ovum with a spermatozoön as occurs in higher animal life, and (2) reproduction by conjugation. In the former, which is less common, individuals come together and their nuclei fuse, while in the latter

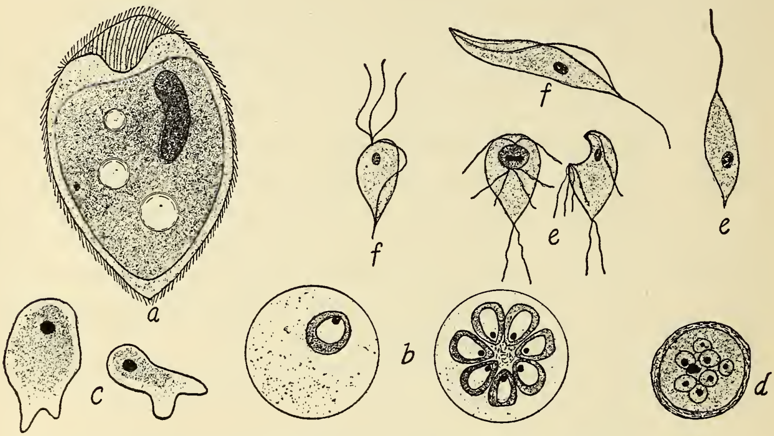


Fig. 18. TYPES OF PATHOGENIC PROTOZOA. (Greatly enlarged.)
a. Infusoria (Ciliate). *b*. Sporozoa (malarial parasite in a red blood cell).
c. Ameba. *d*. Encysted stage of Ameba.
e. Flagellates. *f*. Flagellates with undulating membranes.

the nuclei fuse for a time and when protoplasm has been interchanged the cells separate, each one growing and dividing independently of the other.

Some organisms such as the malarial parasite pass through two cycles, the asexual cycle in man and the sexual one in the mosquito.

Just as some bacteria have the power of passing into a resting or spore stage, some protozoa which do not get the required amount of water, air, or food, or which are otherwise subjected to an unfavorable environment, have the power of *encysting* themselves. In this so-called cyst formation they also may be able to live for very long periods of time. This fact is of considerable importance for many varieties of pathogenic protozoa can be carried in dust and other media.

There are four general types of protozoa: (1) The least frequent parasitic protozoa in man (*Ciliata*) are of the infusorial type and of

little importance. (2) Those which produce large numbers of spores (*Sporozoa*) are of more importance because the very widespread disease, malaria, is caused by parasites belonging to this group. (3) A third group (*Amebae*) when pathogenic cause amebic dysentery and pyorrhea. (4) By far the most important group (*Flagellata*) are responsible for some of the most serious diseases of mankind. Many of the tropical diseases belong to this group: dum-dum fever, Kala-azar, African sleeping sickness (trypanosomiasis), and others. Most scientists agree that the germ of syphilis (*Treponema pallidum*) belongs more to this group than any other, although others feel that there should be a special classification for those organisms which cannot be definitely called bacteria or protozoa, thus leaving open the question of which kingdom should claim them. The matter is an academic one and should not concern one greatly.

Higher Animal Parasites (Metazoa): These fall into a number of groups, and may be best understood when put in outline form.

1. The flukes or trematode worms.
   a. The liver fluke (*Fasciola hepatica*) causes obstruction to the biliary passages, and consequent enlargement of the human liver. It is carried by snails and is ingested by man in the larval stage. The Indian liver fluke (*Opisthorchis noverca*) and the Asiatic liver fluke (*Clonorchis sinensis*) act in a similar manner. The latter type is gotten from the ingestion of the worm in the encysted stage in fish (see Fig. 19 e.)
   b. The lung fluke (*Paragonimus westermani*) has an Eastern habitat also and is ingested in the encysted stage in the fresh-water crab.
   c. Gastrointestinal flukes (*Fasciolopsis buski* and *Echinostoma ilocanum*) also have an Eastern habitat. The latter is found on the island of Luzon in the Philippines and was encountered by U.S. soldiers in World War II. The natural reservoir of infection is in the gray rat (*Mus novergicus*) and carried to man by a snail. These flukes cause dysentery in man.
   d. The blood flukes (*Schistosoma hematobium, Schistosoma mansoni,* and *Schistosoma japonica*) cause the "Katajama disease" of Egypt and other tropical countries. They are ingested in the larval stage in water or in fresh water snails.
2. The tapeworms or cestode worms all require the mechanism of an intermediate host for transmission to man, and for all practical purposes are infective in the encysted larval stage in the meat of animals. There is however one notable exception to this, that of one of the dog tapeworms (*Dypilidium caninum*) which is supposed to be transmitted by dog fleas and dog lice.

a. Pork tapeworm (*Taenia solium*) is an extremely serious infestation usually contracted from eating raw or only partially cooked pork (see p. 83).

b. Beef tapeworm (*Taenia saginata*) is the common tapeworm of man because beef is eaten rare or raw more often than pork.

c. Fish tapeworm (*Diphyllobothrium latus*) is called the "broad tapeworm" because it is the largest one affecting man, often reaching ¾ inch by 20 feet in size.

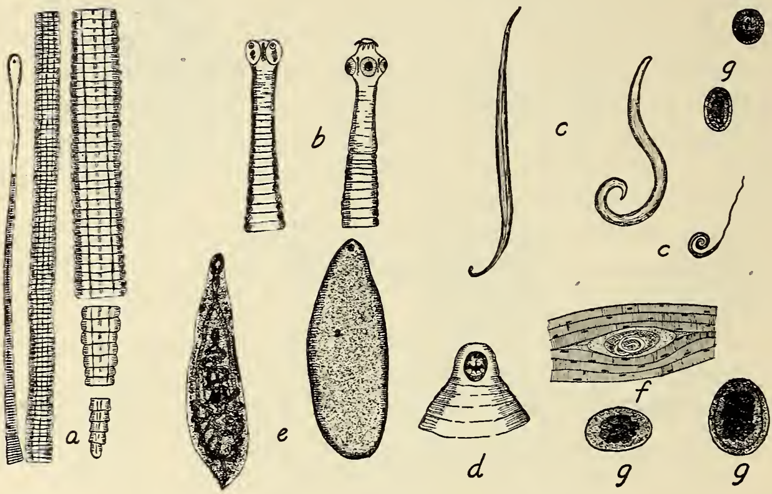


FIG. 19. TYPES OF PATHOGENIC WORMS.

a. Tape worm (fish). *b.* Heads of beef and pork tape worms.
c. Round worms. *d.* Head of a hookworm.
e. Flukes (leaf worms). *f.* Trichina spiralis encysted in pork muscle ("measly pork").
g. Ova of worms (greatly enlarged.)

d. Dog tapeworms sometimes infect man accidentally. There are three common ones (*Echinococcus granulosis, Hymenolepis nana,* and *Dipylidium caninum*).

e. The rat tapeworm (*Hymenolepis diminuta*) infects man by ingestion of food contaminated with rat feces or the feces of rat fleas.

f. The monkey tapeworms (*Bertiella studeri* and *Bertiella mucronata*) sometimes infest man. They are accidentally acquired, usually by laboratory workers who handle monkeys.

3. The thread worms or nematode worms.

a. Guinea worms (*Dracunculus medinensis*) are rarely found outside of the tropics. The female parasite burrows under the skin and deposits its larvae which produce tropical ulcer.

b. The larvae of *Wuchereria bancrofti* or *Trichinella* sometimes invade the blood stream causing a disease called "filariasis," the principal

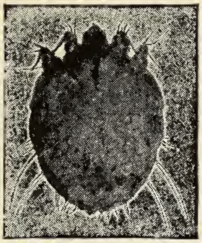


FIG. 20. The female itch mite (greatly enlarged). This organism penetrates the skin and lays a series of eggs in its burrow. These hatch daily and produce the intense itching of scabies.

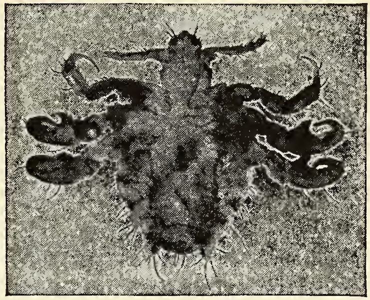
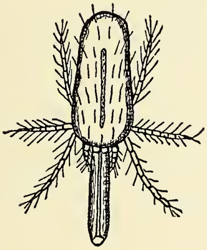
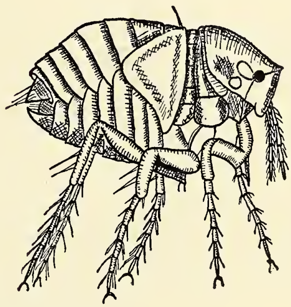


FIG. 21. The crab louse (greatly enlarged). This organism buries its head into the skin and grasps the hair with its claws.

Both Courtesy of Dr. H. L. Claassen





PARASITIC ARTHROPODAE

FIG. 22. Red jigger or harvest bug *(Leptus autumnalis, Thrombidium irritans),* attaches itself to the human skin and sets up an irritation. (Greatly enlarged.)

FIG. 23. Sand-flea (*Pulex penetrans*) penetrates the skin of man producing painful irritation. It is brownish-red and minute in size. (Greatly enlarged.)

symptom of which is an enlargement of the lymphatic tissue especially of the male genital organs (*elephantiasis*).

c. *Trichina* or *Trichinella spiralis,* causing trichinosis, is found as a qui-

escent encysted coiled mass in the meat of infected swine. It is usually contracted by man's eating raw trichina infested pork, usually pork sausages insufficiently cooked.

d. Round worms (*Ascaris lumbricoides*) are very similar in appearance to ordinary earth worms. They sometimes infest man, especially those who live in China.

e. Seat worms or pin worms (*Enterobius vermicularis*), contracted from the soil, usually infest the lower intestines of children, causing them to become very restless.

f. Thread worm or whip worm (*Trichocephalus dispar* or *Trichuris trichiura*) is also contracted from the soil.

g. There are two general types of hookworms (*Necator americanus* and *Ankylostoma duodenale*) which cause one of the most important diseases of the South (hookworm disease or *uncinariasis*). (See Chap. 7.)

h. A series of round worms found usually in tropical or oriental countries (*Strongyloides intestinalis, Rhabditis hominis, Rhabditis intestinalis, Rhabditis miellyi, Belascaris mystox,* etc.).

i. *Onchocerca caecutiens* is found in southwestern United States, Mexico, and Central America. The organism, contracted through the bite of an infected fly, causes tumors of the skin and occasionally disturbances of vision.

4. Arthropodae (Insects, etc.).

The itch mite (*Sarcoptes scabiei* sometimes called *Acarus scabiei*) is a parasitic insect which (the female only) burrows under the superficial layer of the skin. It lays its eggs in the burrow and produces marked itching, which is especially severe at night. The burrows become filled with dirt and are seen as fine lines about ⅛ to ¼ inch in length in the webs of the fingers, on the lower abdomen and other places where the skin is thin. The itch mite, which is only about .015 of an inch long, may be seen with the aid of a lens as a tiny dot at the end of the burrow. Scabies is very prevalent, contagious, and is spread by actual contact or infected clothing.

Lice, flies, ticks, mosquitoes, etc., are discussed in Chap. 12.

Filtrable Viruses: Animate agents of disease capable of passing through the finest known filters are called filtrable viruses. Most authorities agree that the exact nature of a filtrable virus is unknown. It is probably a "living" thing, although the degree of "aliveness" is in controversy. It is a liquid which sometimes contains minute bodies or granules which may be seen with exceptionally high-powered microscopes. Such diseases as smallpox, rabies, yellow fever, mumps, foot and mouth disease, poliomyelitis, dengue fever, and some forms of the common cold are known to be caused by viruses, while such cause is suspected in chicken pox, scarlet fever, trachoma, encephalitis,

epidemic influenza, measles, and German measles. Rocky Mountain spotted fever, formerly thought to be a virus disease, is caused by a very minute organism, *Dermacentroxenus rickettsi.*

In a large number of the virus diseases a single attack will usually produce an immunity of long duration in most individuals. In others, such as common colds and influenza, the immunity is of short duration. Only a minority of bacterial diseases (*e.g.,* typhoid fever and whooping cough) will produce lasting immunity in the subject.

How Organisms Produce Disease: An organism to produce disease must invade some living animal tissue. This we speak of as infection. Parasitic organisms require fresh animal material, for most part, in order to grow and multiply. This fact is well illustrated by the infinite care necessary to keep organisms alive in the bacteriological laboratory. Usually very special culture media are necessary for the various forms; some seem to be so easy to grow in the animal body but so difficult to culture in the laboratory (*e.g., Neisseria gonorrhoeae,* the microbe of gonorrhea). Pathogenic protozoa and other animal parasites, as a rule, cannot be grown outside of living tissue.

One of the most striking effects of infection is "heat" or fever produced within the body. Bacteria produce heat on artificial media which can be measured in the laboratory. The fever may be local as in the case of a boil in the skin, or general as in the case of typhoid fever or pneumonia.

Parasites produce chemical substances which destroy tissue within the body. It is believed (1) that the waste products of bacteria and other organisms cause disease by being a foreign substance in the body, to which the body reacts; (2) that sometimes certain *toxins* are formed, which result in an intoxication (*e.g.,* diphtheria and lockjaw); (3) that disease is produced by destroying tissues of the human body by a process not unlike digestion; and (4) that the parasitic cell itself must build up protoplasm by extracting vital substances from human tissue.

Some parasites act more in a mechanical fashion by not secreting any poisons to speak of but by blocking some vital channel. This is especially true of most of the protozoa and particularly the larger animal parasites.

There is a great selectivity on the part of germs for the animals they prefer and for the various tissues of the animals. Some will grow

only in the blood, others prefer the bones, still others will remain localized in the skin.

The striking effect of parasites upon the body is *inflammation* of various kinds. It is quite obvious that chemical poisons are in some way brought to play upon certain selected tissues. These poisons are either formed within the bacterial cell (*endotoxins*) or are excreted by it (*exotoxins*). They can be recovered by grinding up and extracting from the parasites (bacteria particularly) some of their protoplasmic substances or by washing and filtering the bacteria (the toxin is in the filtrate). The whole problem of bacterial disease and toxins is rather complicated. A brief summary of the situation follows: (1) Bacterial action usually produces poisonous albumins, which are: (a) active protein bodies called *toxalbumins—e.g.,* toxins of diphtheria, tetanus, and botulism; (b) *intercellular toxins* contained within the bacteria, requiring a period of incubation before showing symptoms—*e.g.,* typhoid fever and cholera; (c) *bacterial proteins* such as the bacillus tuberculosis generates (Koch). (2) Sometimes bacterial action produces bases outside of the body which have been called *ptomains.* They are not proteins but are derived from the latter by a splitting off of carbon dioxide from one of the intermediate products of protein catabolism (the carboxyl group of the amino-acids). Ptomain poisoning is not nearly so common as was once supposed, in fact most of the cases of so-called "ptomain poisoning" are really bacterial infections with the *Salmonella* group of organisms. (See Chapter 11.)

Hereditary Disease: Disease may be transmitted hereditarily if a defect be present in the germ plasm of one or both parents. An anatomical abnormality results in the offspring, and this abnormality may express itself as a disease (*e.g.,* diabetes mellitus). Diabetes mellitus results from the degeneration of that portion of the pancreas known as the "islands of Langerhans." The term "insulin" is derived from these "islands." There are over 200 diseases which "run in families."

Congenital Disease: In distinction from hereditary disease, certain conditions may start after fertilization and develop before birth. Such conditions do not have a tendency to recur in succeeding generations. Congenital disease often implies the transmission of communicable disease from mother to fetus *in utero.* Many diseases may be so transmitted, measles, smallpox, chickenpox, and many others. The most

important congenital disease is syphilis which is discussed in Chapter 5.

Lack of a Balanced Diet as a Cause of Disease: There is a sizeable group of diseases caused by improper diet or lack of a balanced diet. Man has gotten his clue to a balanced diet from the composition of the only substance designed definitely by nature as a food, namely milk. Human milk contains on an average 3.5 per cent fat, 7.5 per cent sugar, 1.25 per cent protein, .2 per cent ash, and 87.55 per cent water. Traces of vitamins are also present. We may therefore assume that man needs protein, carbohydrate, fat, inorganic salts, water, and vitamins in about the proportion found in human milk. There is an exception to this statement, however, for the adult who has reached a balance, *i.e.*, is not gaining or losing weight, less protein is needed relatively than for the child. It is quite obvious from the proportions of human milk that in general there are several defects in the diet of most people: (1) too high a proportion of protein, (2) not enough water, (3) no thought as to vitamins.

Man's first idea of a dietary deficiency disease came with his study of scurvy, a scourge that resembled an infection. Scurvy had made its appearances many times in the world's history on long ocean voyages and had been prevalent in Ireland for centuries. Then came a significant change. Sir Walter Raleigh imported potatoes from America in the sixteenth century and the Irish grew them in such quantities that they became known as Irish potatoes. Scurvy receded and disappeared from Ireland after the people began to eat potatoes. The eating of potatoes therefore was correctly credited with the prevention of scurvy as they contain viatmin C. But the disease was more prevalent on shipboard than on land. In 1768, Captain James Cook started on a long voyage from England taking with him fresh meats, onions, and fruits. He compelled his crew to suck lemons. It is said that the compulsion was enforced with the cat-o-nine-tails. At every stop he laid in fresh provisions. He even stowed grass from the South Sea Islands for food. He returned to England three years later after traveling everywhere in the South Seas, with a crew remarkably free from scurvy—theretofore an unknown accomplishment on so long a voyage. He took another trip to the Antarctic for over three years and again returned with a crew free from scurvy.

Scurvy was controlled by the simple device of eating lemons. Today

scurvy is very rarely seen. Occasionally a baby who has not been getting his orange juice develops the disease, but modern scientists have clearly proved to us that vitamin C found abundantly in nature, especially in citrous fruits, will absolutely protect against scurvy of any kind.

The common diseases of dietary origin are: (1) An oriental disease beri-beri (due to lack of vitamin B_1), found among those who live mostly on polished rice and characterized by spasmodic rigidity of the legs, muscular atrophy, paralysis, anemia and neuralgic pains, and death. (2) Pellagra (due to a lack of niacin), a more or less similar disease found in the southern part of the United States among those who live on a monotonous diet of corn and corn products and characterized by painful skin and subcutaneous tissue,. indigestion, muscular weakness, and often insanity. This is also fatal as a rule. (3) Scurvy (due to a lack of viatmin C), once so prevalent on shipboard, now rarely seen except in infants improperly fed, is characterized by general weakness, soreness and bleeding of the gums, loosening of the teeth, and hemorrhages under the skin. It is amenable to treatment and is not usually fatal. (4) Rickets (due to a lack of vitamin D) is a common disease of infancy especially in Negro children. It is believed that because of the pigment in the skin of Negroes the effect of ultraviolet light in sunshine is not felt in these babies, and they are not able to generate their own vitamin D. The skin of the Negro is admirably adapted to tropical sunshine but not to cities in the temperate zone. The symptoms of rickets are lack of normal growth, restlessness, fever, weakness, profuse sweating, and bending of the bones. It is usually amenable to treatment, which includes a balanced diet, cod-liver oil, and ultra-violet irradiation of the child or the feeding of irradiated substances.

Deficiencies Which Produce Disease: Lack of iodine in the water or foods leads to endemic goitre. This is especially noticeable in mountainous regions such as Switzerland and other places, and in the Great Lakes region of the United States.

Lack of sunshine predisposes to tuberculosis, respiratory infections, skin infections, and some general diseases, *e.g.*, rickets.

Lack of proper ventilation brings on symptoms of "crowd poison" such as occurred in the famous Black Hole of Calcutta. This disease

is due to lack of air movement, too much moisture in the air, and too high a temperature.

Transmission of Communicable Diseases: Communicable disease is transmitted either by direct contact or by some of the following special mechanisms: (1) Sometimes human beings carry a disease after having had it and recovered; they are known as human carriers. (2) Sometimes inanimate objects carry disease. The air was thought of as a common agent of this sort in the past. Malaria derived its name from this concept as "bad air" was considered to be its cause. Polluted water is known to carry such diseases as typhoid fever, dysentery, cholera, and other gastrointestinal infective disorders. The soil often carries bacteria causing wound infections such as tetanus and gas bacillus infection, as well as hookworm and some other worm infestations. Food has been one of the principal offenders of this sort. Milk has carried a large group of human diseases in cases where a sick worker handling milk accidentally inoculated the milk with bacteria which he was harboring. Other food may carry disease in the same manner. (3) Animals are fairly common agents in transmitting disease. (4) Insects carry diseases such as malaria, yellow fever, dengue, etc.

The distribution of disease varies with the type of disease. Those which are readily communicated by contact infection are widespread, even sometimes world-wide. They are often spoken of as "endemic" diseases because they always seem to be present among the people.

Endemic Diseases: When a disease is peculiar to a certain locality or limited to a class of persons, it is said to be endemic in that locality or among those people. Endemic disease is constantly present. Measles, mumps, chicken pox, whooping cough, scarlet fever, influenza, pneumonia, tuberculosis, syphillis, gonorrhea, and many others are endemic in the United States. Trachoma is endemic in certain regions of the United States and absent in others. Yellow fever is endemic in certain localities in South America and Africa but does not occur in Europe, Asia, or North America. A large number of diseases are endemic in the tropics only.

Epidemic Diseases: When a communicable disease attacks a large number of people in a short space of time, it is said to be epidemic in nature. Most endemic diseases become epidemic at times. When the incidence of a certain communicable disease reaches epidemic proportions it is apt to be more severe in the individual case and is usually

accompanied by a higher mortality rate. It is not possible to state just how many cases of a disease constitute an epidemic. The term is relative and loosely applied. Epidemics do show certain characteristics which will be discussed in Chapter 16.

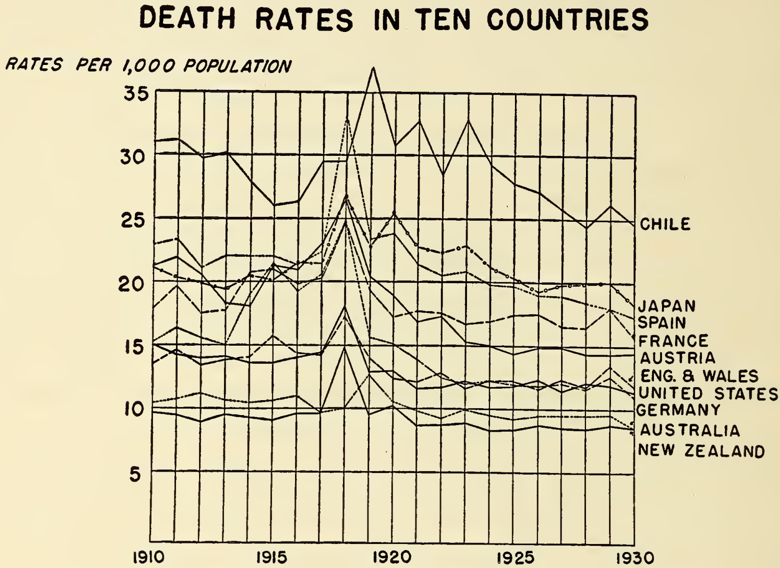


FIG. 24. The sharp rise in the death rates in 1918 and 1919 was caused by the influenza pandemic in those years.

Pandemic Diseases: When a disease is epidemic in a great many places in the world at the same time, it is said to be pandemic. Communicable diseases such as influenza, plague, and Asiatic cholera have become pandemic a number of times in the past. In 1918-19 influenza was pandemic, and all countries showed an increased death rate due to the added number of deaths from this disease. (See Figure 24.)

Such diseases as tuberculosis and syphilis are not usually regarded as pandemic although they are prevalent throughout the world. Perhaps because of their chronic nature these two conditions are regarded as endemic everywhere rather than epidemic, and thus do not come within the definition.

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4

IMMUNOLOGY

Ancient man conceived the idea that protection against certain diseases might be obtained by giving a human being a mild attack of a prevalent disease in order to protect him against a serious attack of the same disease. The first definite practice of inoculation came about in an attempt to escape the ravages of the dread smallpox. It is said that inoculation with smallpox material taken from the pustules (or vesicles) on a smallpox patient was practiced in India for over a thousand years before the Christian era, and that throughout the ages evidence indicates that even primitive man sometimes practiced some kind of immunology. For centuries the Chinese placed the dry scabs of smallpox lesions into the nostrils to give children a milder case of smallpox than that obtained when they were naturally exposed.

The past has given us a certain amount of evidence that in addition to the Hindus and Chinese above mentioned, the Arabs, certain African tribes, and the Turks practiced inoculation. It was in Turkey that Lady Mary Wortley Montagu, the wife of the British ambassador to Constantinople, found that the practice of inoculation had been carried on for a long time and had her own son "engrafted" with smallpox material. This gave the boy an attack of smallpox called *variola inoculata,* which was invariably milder than true smallpox, *variola vera,* contracted in the normal way. She wrote in 1717 to her friend Miss Sarah Chiswell in England, saying:

"I am patriot enough to take pains to bring this useful invention into fashion in England."

By 1723 Lady Byng inoculated both her children, according to Lady Mary. People of the highest rank on the Continent and in England began the practice of *variola inoculata,* because everyone expected to contract smallpox at some time in their lives. Indeed De la Condamine in the middle of the eighteenth century considered it "a river that everyone had to cross" and estimated that "smallpox caused one-tenth of all deaths, and that one-fourth of mankind were either killed,

crippled, or disfigured for life by it." The painters of the portraits of George Washington, save one, have kindly erased the pock marks from his face, but in the Masonic Lodge at Alexandria, Virginia, there is a picture of Washington by Williams which shows him to be distinctly marked by the disease.

Dr. Thomas Dimsdale (1723-1800) carried the practice of inoculation far in England, becoming really a specialist in that line. In 1768, he inoculated the Czarina Catherine of Russia and the Grand Duke Paul for which he is said to have received a fee of $50,000 and was created a Baron of the Russian Empire. In 1781, he made a second trip to Russia and inoculated Czar Alexander and the Grand Duke Constantine.

Benjamin Franklin in his autobiography writes:

> In 1736 I lost one of my sons, a fine boy of four years old, by the smallpox taken in the common way. I long regretted bitterly, and still regret, that I had not given it to him by inoculation. This I mention for the sake of parents who omit that operation, on the supposition that they never should forgive themselves if a child died under it; my example showing that the regret may be the same either way, and that therefore the safer should be chosen.

This was writen about 1788 and shows that inoculation was still practiced but that some people feared to lose their children. There was a further difficulty which soon became apparent when smallpox began to become epidemic in places where it was not naturally expected, because inoculated smallpox was just as contagious as true smallpox. Some realized also that syphilis could be transmitted in the person-to-person inoculation. It was not until 1840 that *variola inoculata* was prohibited by act of Parliament in England. By that time the practice of vaccination was well under way.

For a long time farm hands were familiar with the disease "cowpox" which they observed in cattle and then noticed that they could and did contract the disease in milking the cows. The country people then noticed that they did not contract smallpox after they had had cowpox and when inoculated were not able to have a case of *variola inoculata*. This view was held in various places on the Continent as well as in England and Ireland. Cowpox was never fatal whereas inoculated smallpox was at times. One cannot say who first conceived the idea of transferring cowpox to man in order to protect him from smallpox.

In a churchyard of Worth Matravers, England, there is this inscription on a tombstone:

Sacred
To the Memory
of
Benj^{n} Jesty (of Downshay)
Who departed this life
April 16th, 1816
Aged 79 years

He was born at Yetminster in this County, and was an upright Honest man; particularly noted for having been the first Person (known) that introduced the Cow Pox by inoculation, and who, from his great strength of mind, made the experiment from the Cow on his wife and two sons in the year 1774.

It is said that in the face of an epidemic in Yetminster, Jesty took his family to a neighboring farm where cowpox existed in a herd of cattle and vaccinated them by taking the material from the blisters on the cows and transferring it to his wife and children by means of a scratch. His wife's arm became severely inflamed and he kept very quiet about what he had done.

Edward Jenner, born in Gloucestershire in 1749, is accredited with being the real scientific discoverer of vaccination. He studied medicine under the famous John Hunter in London where he resided for two years (1770-72). He had heard from the country folks that having had cowpox was a protection against smallpox, but had not known of Jesty's original vaccination in 1774. In 1789, Jenner vaccinated his son Edward with swinepox material, there being no cowpox material available. He then attempted to give him *variola inoculata* but was unsuccessful. Later however the child did show some reaction to inoculation. Indeed, upon investigation it was discovered that farm hands who had had cowpox occasionally contracted smallpox subsequently. This was confusing. We now know that the immunity produced by vaccination is of limited duration and not usually lifelong.

The principles of Jenner have long stood as the basis of practically all work in immunology. His *Inquiry into the Causes and Effects of Variolae Vaccinae* published in 1798 is a classic known to all subsequent workers. In 1800, Benjamin Waterhouse introduced Jennerian vaccination into New England. By 1802, vaccination had been established in Berlin. In 1805, Tropa of Naples discarded arm-to-arm

vaccination for inoculation of cows from human subject or retrovaccination. By 1807, compulsory vaccination began to make its appearance beginning in Bavaria and Hesse in Germany. In 1818, Glasgow instituted a "Cow Pock Institute." In 1821, the Academy of Medicine of Paris instituted a Vaccine Service.

FIG. 25. "The cow-pox; or, the wonderful effects of the new inoculation." From a caricature of Edward Jenner, 1802. Antivaccination propaganda began with the introduction of cowpox inoculations. It was prophesied that those who had been vaccinated would grow horns.

Courtesy Burroughs, Wellcome and Co., London and New York

It was not until 1844 that Negri first obtained smallpox vaccine by inoculation from cow to cow, the method in vogue today for obtaining virus uncontaminated with human disease.

In 1822, there was born at Dole in France one of the greatest figures in science, Louis Pasteur. He was the son of a local tanner who had ambition for his son and sent him to study at Besançon. He graduated from the École Normale in Paris in 1847 and began a career of teaching as professor of physics at the Lyceum at Dijon (1848). From 1852 to 1854 he held the post of professor of chemistry at the University of

Strassburg; from 1854 to 1857 at Lille; from 1857 to 1863 at the École Normale at Paris; from 1863 to 1867 at the École des Beaux-Arts; from 1867 to 1889 at the Sorbonne; and from 1889 to 1895 (at his death) at the Institut Pasteur. Pasteur was primarily a chemist and demonstrated for the first time molecular dissymmetry in chemical substances. He became interested in disease and immunity through his studies on fermentation, which brought him to the discovery that spoilage in

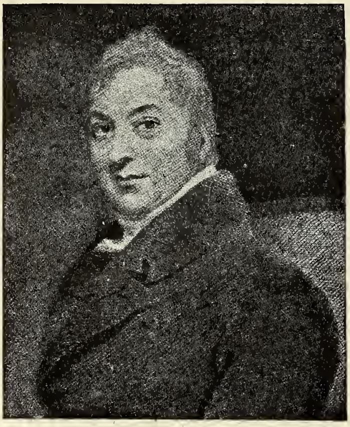

Fig. 26. EDWARD JENNER
1749–1823

Fig. 27. LOUIS PASTEUR
1822–95

wine was of bacterial origin. He discovered that the microorganisms causing wine to spoil could be destroyed by heat, and the taste of the wine could be preserved if just enough heat were applied to kill the organisms but not enough to boil the wine. This process of *pasteurization* is today applied to milk to render it safer. Pathogenic bacteria are destroyed but the food elements are preserved.

Pasteur was called on to prevent the diseases which were attacking the silk worms in the hope that this industry could be saved for France. In this he was not successful. Anthrax had threatened the wool industry by killing off the sheep in large numbers, and he set about the prevention of this disease. Pasteur quite accidentally made the discovery of an *attenuated virus,* which is the basis of modern immunology. Returning one time from a vacation and taking up the problem of chicken cholera, he inoculated some of his old cultures

into some fowls with no result. He thought his virus sterile and again inoculated the fowls with what he knew to be virulent virus, but the fowls refused to sicken. He was wise enough to see that he

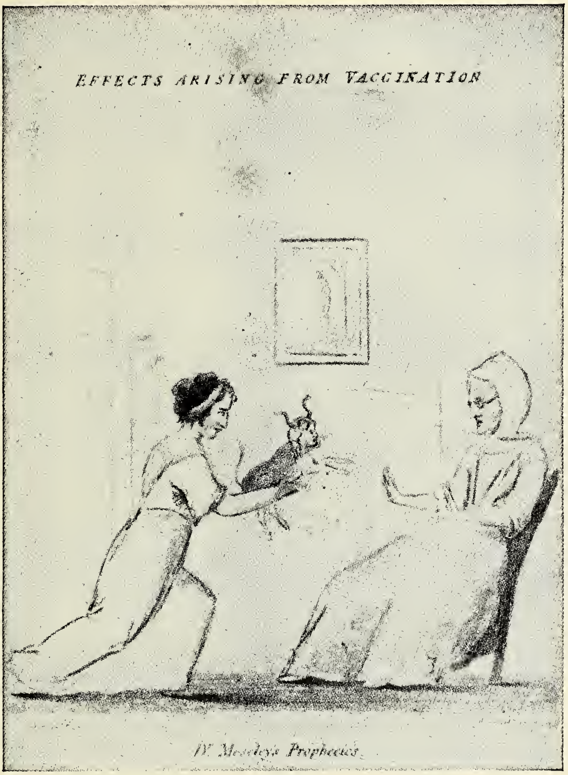

FIG. 28. "Effects arising from vaccination." From a caricature. 1806. One Dr. Moseley prophesied that those who were vaccinated would give birth to children with horns, hair, and hoofs.

Courtesy Burroughs, Wellcome and Co., London and New York

had immunized his animals against a virulent disease by means of an *attenuated virus,* a virus which had been weakened. In 1881, he succeeded in making a vaccine for use in preventing anthrax by keeping his culture of anthrax at 42-43° C. His dramatic demonstration of the

efficacy of his vaccine is vividly described in Vallery-Radot's *Life of Pasteur,* Chapter X.

Using the same principle he made an attenuated virus for hydrophobia or rabies. The attenuation of the virus was obtained by taking the rabies virus from the saliva of a mad dog and passing it through a series of rabbits (using the spinal cord for inoculation). The virus thus became more virulent for rabbits but less virulent for dogs and man until finally it could be given with safety. Pasteur's experiments on animals had been highly satisfactory. In July, 1885, an Alsatian boy, Joseph Meister, was brought to him badly bitten by a mad dog. With great anxiety Pasteur tried his virus on Joseph and successfully averted the rabies which the boy, by reason of the severity of the bites, was sure to have without this protection. The news of this accomplishment spread rapidly and soon people who had been bitten by rabid animals were flocking to Paris for the prophylacitc treatment begun by Pasteur. Herman Biggs, Health Commissioner of New York City, took several small boys to Paris for this prophylactic treatment before any prophylaxis was available in this country. Soon Pasteur Institutes sprang up all over the world where people could go to receive the necessary inoculations.

Fig. 29. This monument erected in front of the Pasteur Institute in Paris to commemorate Pasteur's successful vaccination against rabies shows the shepherd boy Jean Baptiste Jupille wrestling with the rabid dog that bit him while he was protecting some younger children. The boy was vaccinated six days later and was one of Pasteur's earliest subjects. The man standing beside the statue was the prototype.

Courtesy *Hygeia*

In 1887, Roux and Yersin, two disciples of Pasteur, tackled the problem of diphtheria, then one of the most lethal of diseases for small children. These Frenchmen (Pasteur and his students) were tender-hearted, and those diseases affecting children greatly interested them.

FIG. 30. EMIL A. VON BEHRING
1854–1917

They had already been wonderfully successful in preventing rabies. Their keen powers of observation led to an important scientific discovery, that of the *exotoxins* (see p. 54). When diphtheria bacilli were taken from the throats of children ill with the disease, grown in flasks of broth, and inoculated into rabbits, the latter invariably became paralyzed in the legs just as children did. When the rabbits were in-

vestigated by post-mortem examination no bacilli could be found in any of their tissues. Roux and Yersin tried filtering the diphtheria bacilli after they had been growing in the laboratory for several days and using the filtrate for inoculation. This filtrate did not produce the characteristic symptoms. However, when the bacteria were allowed to grow for a long time (42 days, in their experiments) and then filtered, the filtrate, which was clear and contained no organisms of any kind, produced definite paralysis in guinea pigs or rabbits. This showed that the diphtheria bacillus *slowly* excreted a poisonous substance or a *toxin*. At the same time, working independently in Robert Koch's laboratory in Berlin, Emil von Behring made similar experiments and discoveries. Von Behring however went further. He inoculated guinea pigs with diphtheria bacilli, and from those who survived he extracted the blood serum. He mixed the serum with the toxin of diphtheria and inoculated a fresh guinea pig. Nothing happened. The blood serum of the immune guinea pig had neutralized the toxin of diphtheria in the filtrate of a laboratory culture. Using the serum of a fresh susceptible guinea pig, and mixing it with the known toxin, produced paralysis in another susceptible guinea pig. Therefore the serum of the immune animal must contain something which neutralizes, and renders harmless the deadly toxin of diphtheria. This was called "antitoxin" and the details of its manufacture is described below. Realizing that he had a powerful weapon against diphtheria he began his inoculations with diphtheria antitoxin in 1891. A child desperately ill with diphtheria in a Berlin hospital was given antitoxin by him and promptly recovered.

In the meantime, Roux, who had been performing similar experiments, managed to immunize horses, and thus manufacture the antitoxin in large amounts. He reported his results to the International Congress of Hygiene at Budapest in 1894 and showed a prompt reduction in mortality after the use of antitoxin.

When diphtheria antitoxin was used in the treatment of the disease, some children who had received it subsequently developed second, third, or more attacks. Inasmuch as the horse had actively produced the antitoxin in its own blood serum and the child had passively received this antitoxin, a distinction was discovered between *active* and *passive* immunity. The latter was of short duration and was not of much use as a prophylactic measure except when the child was known

to have been exposed to diphtheria. But the knowledge of exposure being a somewhat uncertain thing the full protection against diphtheria could not be obtained by the passive method of immunization, *i.e.,* the administration of diphtheria antitoxin. In 1913, Von Behring

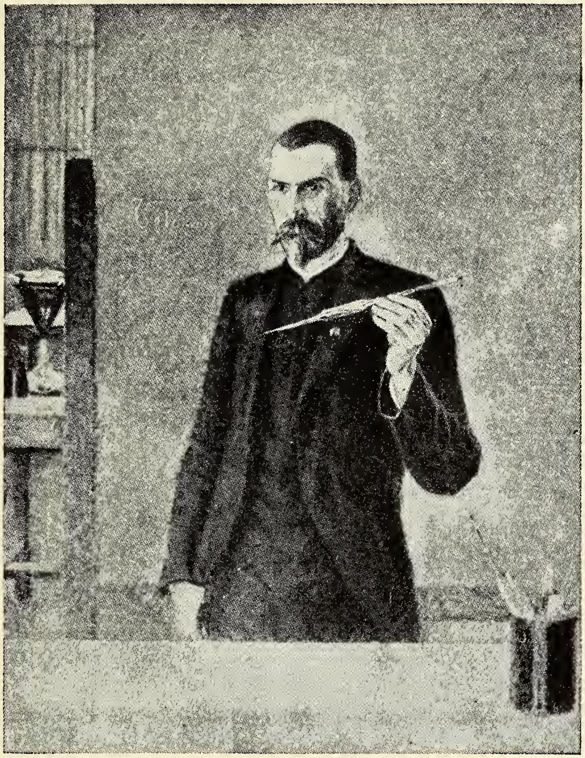

Fig. 31. PIERRE PAUL EMILE ROUX
1853–1933

used a mixture of toxin and antitoxin to give active immunity to children. In 1908, Bela Schick of Vienna had discovered that by an injection of a small amount of diphtheria toxin under the skin it was possible to determine whether or not an individual possessed immunity to that disease. The Schick test became a very significant and important test when active immunization was practiced on a

large scale. Most children under six years of age, preschool children, are susceptible to diphtheria. When these children were given toxin-antitoxin and later given a Schick test it was possible to deteremine whether or not they had developed an immunity. If no local reaction of inflammation to the injected material of the Schick test resulted they were considered immune. If, however, a local area of redness and swelling developed at the site of the injection, the child showing this positive Schick test was considered to be susceptible to diphtheria in spite of the injection of the toxin-antitoxin. Such eventuality required repeated inoculations of immunizing material until immunity had been obtained.

In 1924, Ramon of Paris developed a detoxified toxin which has replaced toxin-antitoxin as an immunizing agent. If diphtheria toxin is treated with either of two chemicals, potash-alum or formalin, its toxic nature is changed but its immunizing properties are retained. Ramon called his detoxified toxin "an*a*toxin" which is synonymous with "toxoid" the substance now used to give active diphtheria immunization. This disease, so prevalent in the nineteenth century, is today comparatively uncommon. (See Fig. 32)

The success obtained with diphtheria antitoxin seemed to indicate that the serum of immune animals could be applied to a number of different diseases. So far these results have been rather disappointing. Tetanus antitoxin, scarlet fever antitoxin, botulinus antitoxin, and snake venom antitoxin, however, are definitely valuable if given before the advent of symptoms.

In 1884, Elie Metchnikoff (1845-1916), the famous Russian biologist, discovered that the wandering cells of the body of the water flea (*Daphnia)* surrounded and absorbed bacteria and other and more solid organic matter. This phenomenon he called *phagocytosis* and demonstrated that the white blood cells are particular scavengers in certain diseases. In 1888, G. H. F. Mittall showed that body fluids, especially blood serum, contained antibacterial properties. In 1894, Pfeiffer showed that when cholera spirilla had been introduced into the peritoneal cavity of guinea pigs immunized against cholera, that the spirilla broke up into small granules. This became known as *bacteriolysis* or "Pfeiffer's phenomenon." Metchnikoff produced the same thing by mixing immune blood sera and organisms in a test tube.

In 1895, Bordet noticed that when a small amount of immune serum

was added to a culture of cholera spirilla, these lost their mobility and clumped together in a peculiar manner; he called this *agglutination.*

In 1899, Sir Almroth Edward Wright of Dublin, Ireland, during the Boer War inoculated the soldiers with cultures of killed typhoid bac-

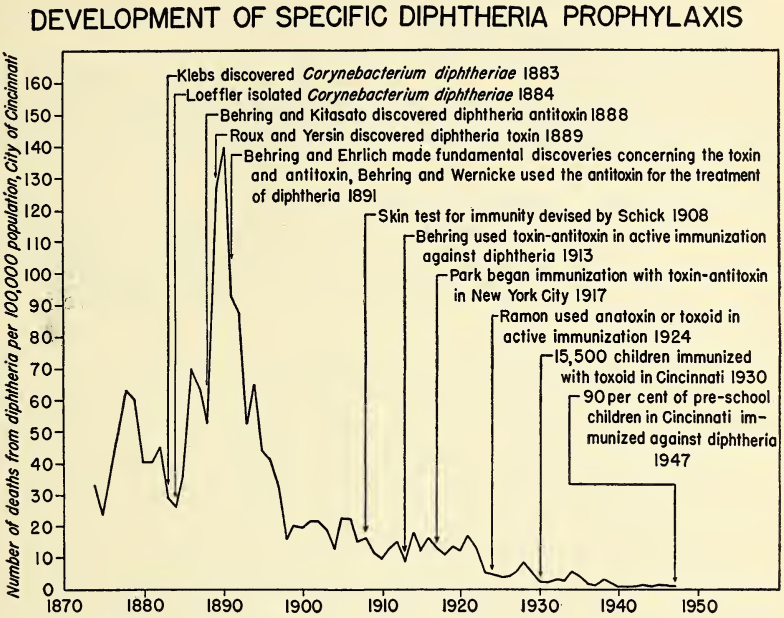

FIG. 32. The successive steps in the development of specific diphtheria prophylaxis. The mortality rate from diphtheria was high in the nineteenth century throughout the civilized world. Scientific discoveries in Europe were soon applied everywhere but marked reduction in incidence of diphtheria morbidity and mortality did not occur until after active immunization had been practiced extensively.

Data for this chart was furnished by the Board of Health of the City of Cincinnati

teria (bacteria killed with heat). The inoculated soldiers developed very little or no enteric fever (enteric fever is a term often applied to typhoid or paratyphoid fevers). When the bacteria had been first used in making the vaccine too high a temperature had been used for killing them. When the temperature was reduced to 53° C and phenol added better results were obtained.

In 1898, during the war with Spain, typhoid fever was much more

disastrous to the American army than Spanish bullets. When the American army was mobilized on the Mexican border in 1911 there were three divisional camps. The soldiers had all been given typhoid-paratyphoid vaccinations. In over 20,000 men there were only four cases of typhoid fever. The results in prophylaxis in World War II were excellent. No deaths from typhoid or tetanus have been reported from the armed services.

Other diseases came to be controlled by inoculation of specific material. Halfkine in 1897 proposed anti-plague inoculation. This was made of a broth culture of *Pasteurella pestis* which had been sterilized by heating to 65° C.

In recent years convalescent human blood serum and immune serum globulin have been used in an attempt to control poliomyelitis (infantile paralysis), measles, scarlet fever and other so-called children's diseases. Serum globulin has been particularly effective in preventing measles.

A final page in the history of immunization remains to be told. Paul Ehrlich (1854-1915) is responsible for a theory of immunity which has received widespread attention, the so-called "side chain" theory. According to this theory a molecule of protoplasm contains unstable side chains which can combine with and neutralize toxins by detaching side chains into the blood. His most important contribution, however, has to do with syphilis and other protozoan diseases, in which he attempted to find a substance which would kill the germ and at the same time not kill the patient. This he succeeded in doing when he discovered salvarsan or 606 (the 606th substance tried).

Immunity is a general term, not confined to disease wholly, yet today immunity is usually thought of with reference to a man's ability to resist and overcome infection. It is a function of all living things, and can, to a certain extent, be measured. It also has many modifications such as: racial immunity or that enjoyed by certain races; familial immunity or that which is inherited or is peculiar to certain families; natural immunity or that with which the individual is born. Natural immunity is often thought of as a general term to cover familial and racial immunity.

Immunity is either natural or acquired. Some also claim that it is either general or specific. However our scientific information would seem to indicate that immunity is specific. This is unfortunate in a-

way, especially when attempting to give immunity artificially by vaccines, for it is necessary to give a large number of vaccines to protect against an equally large number of diseases. Smallpox vaccine will protect against smallpox (and cowpox which may be a form of smallpox) only, and not against diphtheria.

OUTLINE OF IMMUNITY

I. Natural immunity then is inherited and is more specifically the resistance exhibited by body tissues of a given species to disease. It may be due to metazoic temperature, each organism having an optimum temperature for growth. It may be due to inherited specific antibodies. Many diseases of other animals are not transmissible to man because of natural immunity. Susceptibility is an antonym or opposite term.

II. Acquired immunity is specific and of two kinds:

1. Active immunity, is that form in which the individual builds within his tissues (either locally, in some tissues, or generally in some circulating medium like the blood, lymph or other fluids of the body) a specific resistance to a disease. The term implies that the individual himself manufactures the antibodies which will remain for some length of time at least in his body. This time varies with some known but many unknown factors. Active immunity is acquired in several ways, viz:

   a. An attack of a disease. Most immunity is acquired in this way. Of the diseases which confer an immunity of some years' duration the following are outstanding examples: Typhoid fever, paratyphoid fever, scarlet fever, whooping cough, the plague, yellow fever, smallpox, cowpox, chicken pox, measles, German measles, mumps, typhus fever and others. The length of the immune period depends upon the number of antibodies produced. In some cases the immunity is probably very mild and of short duration as, for example, in certain types of the common cold, influenza, pneumonia, gonorrhea and other very common diseases. Second or third attacks of measles, scarlet fever and other childhood diseases, though rare sometimes occur. However, it has often been noticed that even a very mild attack of a specific disease previously experienced will protect an individual in a severe epidemic of the same disease.

   b. An attenuated virus is the next most common way of acquiring an active immunity. This attenuation may be brought about in a number of ways:

      1. By growing the organisms in a less favorable animal. In smallpox vaccination the virus has grown so long in cows that it no longer possesses the same virulence for man. Therefore when used it gives only a mild disease called vaccinia (or a "successful vaccination"). The same, in part, is true with reference to rabies (see Chap. 10).

      2. Drying causes an attenuation of a virus and was made use of in

making antirabies vaccination virus. The brain stem (medulla) and the spinal cord of rabbits which had been inoculated with fixed rabies virus were removed from the rabbits after death and suspended in a jar with sticks of sodium or potassium hydroxide in the bottom of the jar and tightly corked. The chemical had such an affinity for water that it absorbed the latter from the brain stem and cord and weakened

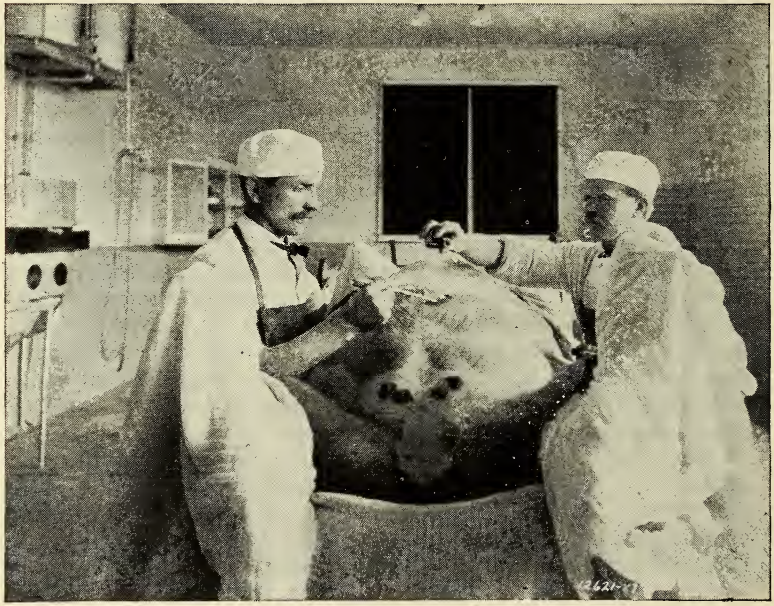

FIG. 33. Preparing cowpox virus, or smallpox vaccine.
Courtesy Parke, Davis and Co., Detroit

it in proportion to the amount of water absorbed. In other words the longer the cord was dried the weaker it became. In increasing the doses for the prophylactic treatment of rabies, Pasteur simply gave hypodermically a cord ground up and suspended in a weak salt solution, this cord having been drying a less time than the former one used. The first dose of the original attenuated virus given to Joseph Meister by Pasteur was a cord which had been drying for 14 days. On the tenth day he gave the final dose of the suspension of a ground cord which had been drying but one day. The fundamental treatment has not varied since Pasteur's time.

3. Growing an organism at a higher temperature than is optimum for that organism was also made use of by Pasteur in developing a vaccine for anthrax.

c. Dead organisms are more generally adaptable for vaccines than living or attenuated ones. They may be used in a larger number of specific diseases. They are easier of preparation and in many cases quite as efficacious. It is believed that the toxins within the bacterial cells or the endotoxins are all that are needed to produce active immunity in some cases. Therefore by killing the bacteria, and at the same time not destroying the endotoxins a relatively large amount of toxins may be administered with safety because the vaccine can be more accurately measured and standardized. Suspensions of dead organisms in normal salt solution are called "bacterins" to differentiate them from viruses. The term vaccine came originally from the word "vacca" meaning a "cow," and was used for cowpox vaccination. Usage however has ascribed the term vaccination to any protective inoculation used for the prophylaxis or treatment of any disease.

d. Toxins when administered hypodermically give an active immunity. This is especially true of diphtheria toxin, but untreated diphtheria toxin (or any other for that matter) is too virulent a substance to be administered in pure form. Soluble toxins, or exotoxins, are those excreted by the organism, while it is growing in the laboratory. If the medium is filtered through a fine filter the organisms will be removed, but the toxin will be found in the filtrate. In administering a toxin it is necessary to detoxify the toxin with some chemical substance which will combine with it to some extent, and thus reduce its virulence. Formalin and potash-alum are detoxifying agents.

e. Bacterial extracts are not extensively used but show some promise of a refinement and more accurate standardization in vaccine use. The living bacteria are mixed with alcohol, glycerin, or other substances, then filtered. The filtrate is given hypodermically.

f. Alcoholic antigens have been used for immunization. An antigen is any substance producing or stimulating the production of antibodies, hence any vaccine is an antigen. The term has been used for poison ivy vaccine made by extracting material from the plant for inoculation purposes.

2. Passive immunity is that form of acquired immunity where the tissues of the individual do not actively produce antibodies to combat disease. The classical illustration is the antitoxin. Antitoxin is made for the prevention or treatment of diphtheria, tetanus or botulism, where true toxins are produced. It is manufactured in some other animal, usually the horse, because of his size, and the greater toleration man seems to possess for horse serum. A horse to be used for the production of antitoxin is first carefully examined by a veterinarian. He is then inoculated every two days with a small amount of (diphtheria) toxin previously neutralized with a small amount of antitoxin from another horse. Originally this was not done, but the toxin used only. But with the antitoxin a larger dose can be given with greater safety for the horse. The dose is gradually increased until the final dose given him is 150 or more times as strong as the initial

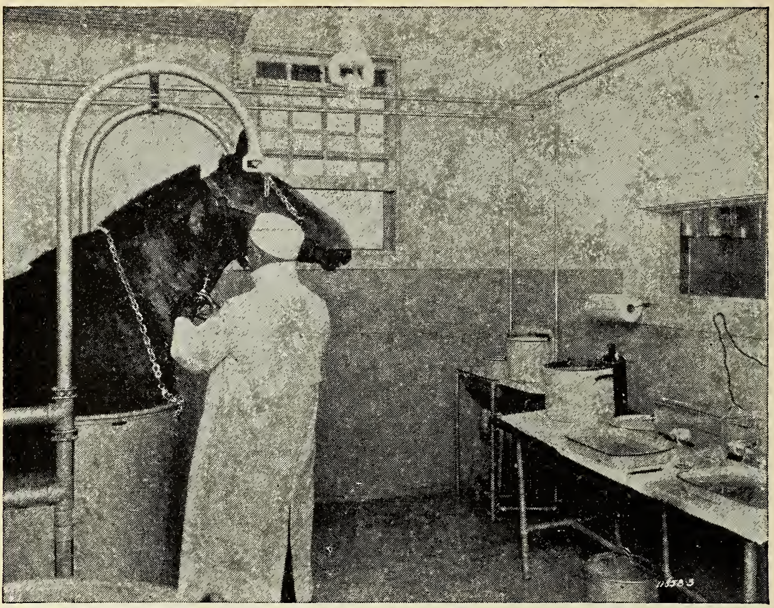

FIG. 34. Injecting "serum horses" for the manufacture of antitoxin.

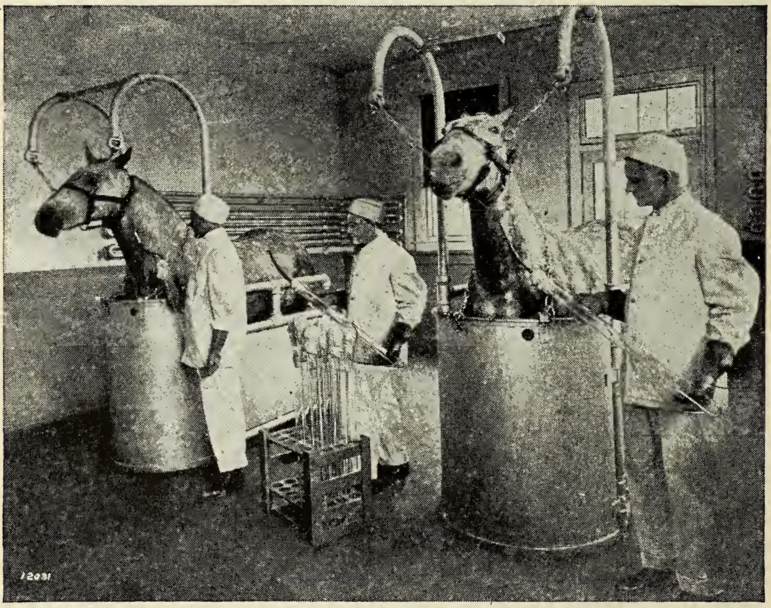

FIG. 35. Bleeding "serum horses" to collect blood serum for antitoxin.
Both Courtesy Parke, Davis and Co., Detroit

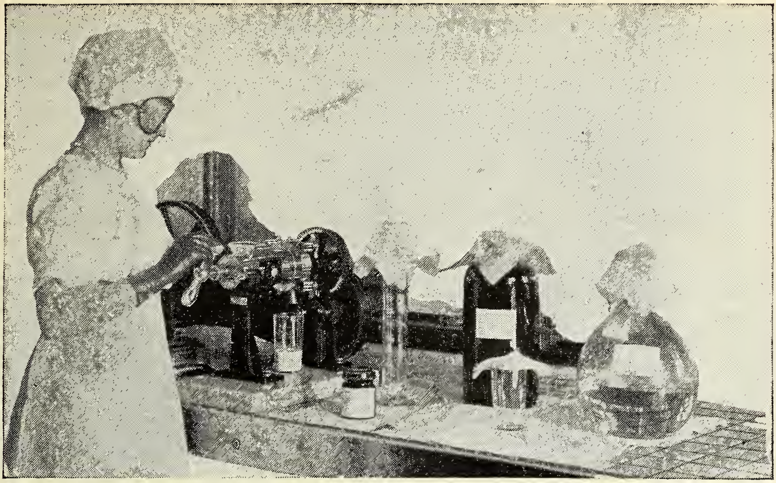

Fig. 36. Aseptic tissue grinding in preparing vaccines.

Fig. 37. Putting up vaccines in the final container, asepsis being observed.

Both Courtesy Parke, Davis and Co., Detroit

one. In eight or more weeks the horse has produced antibodies in his blood which will combat diphtheria when given to a child with the disease. Blood is carefully removed from a neck vein and collected in surgically clean utensils. The blood is allowed to stand in a refrigerator until a definite clot has formed, or is beaten to remove from the blood the parts which will form a clot. Very often it is necessary to filter, and add disinfecting substances as well. Some antisera stop here (*e.g.,* tetanus antitoxin)

Fig. 38. Serum direct from the horse, freshly supplied. From a German Caricature of von Behring.

Courtesy of Burroughs Wellcome and Co., London and New York

but diphtheria antitoxin must be carried further. Ammonium sulphate is added to the serum, and filtered. The antitoxin is found in the precipitate, or the substances remaining on the filter. The filtrate, or that which goes through the filter, is discarded, and the precipitate further purified by dialysis. This after more antiseptic treatment is finally filtered, diluted, standardized, and put up ready for use. The antitoxin thus purified and refined is not quite as potent as the original serum, but it is much safer for practical clinical use, and contains much less crude serum. Meanwhile the horse is not in any way harmed in spite of repeated bleedings. The horse is re-inoculated from time to time however to keep up the potency of his blood serum.

Another form of passive immunity is illustrated in the use of some drugs or chemicals for the prevention of disease. Some such substances have had extensive use, quinine, mercury and salts of silver, and other local antiseptics. The use of tincture of iodine (and other local antiseptics) on open wounds prevents an enormous amount of local infection. This is really a form of practicing passive immunity from sepsis. But more specifically quinine or atabrin may be taken constantly in mosquito infested areas where malaria is prevalent for the passive immunization against malaria. The drug circulates in the body, and kills plasmodia before they have a chance to become established. Similarly mercury, or some of its salts may be used in the prevention of syphilis by rubbing them into the skin of the parts exposed. Certain forms of mercury (blue ointment for example) may be absorbed and circulated in the body to further prevent syphilis. This is a part of the Army prophylaxis mentioned in Chapter 5 the effectiveness of which is questioned.

All of these forms of passive immunity however do not give any lasting protection against the disease for which they are used. In the case of antitoxins the immunity may last some months, but very rarely a year or more.

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5

CONTACT INFECTION

Historical Considerations: There are many statements in ancient Jewish literature which indicate that these people had definite ideas concerning contagion (see p. 40). Such ideas were not accepted in Western countries until comparatively recent times. Ambroise Paré, the famous French military surgeon of the sixteenth century, made an important discovery by chance. In ancient and medieval wars it was the custom to pour boiling oil into the wounds of soldiers before dressing these wounds. On one occasion, his boiling oil having been exhausted, Paré was compelled to dress the wounds without any preliminary treatment. Such wounds healed more readily than those treated in the conventional manner and Paré continued the practice. The natural resistance of the body to infection caused better healing in the untouched wound than in the one where the tissue had been damaged by the boiling oil. In the latter case this natural resistance was impaired. Paré was severely criticized by his contemporaries but he answered them with the reiteration of the simple statement, "I dressed his wounds and God healed him." [1]

The ancients had no real concept of contagion except the Jews and their neighbors, who recognized the antiseptic qualities of certain substances such as wine and balsams. The Good Samaritan poured wine and oil into the wounds of the man who had fallen among thieves and bound up these wounds. The modern concept of contagion began with the doctrine enunciated by the famous American physician, teacher, and poet, Oliver Wendell Holmes. In 1843, Dr. Holmes, a practicing physician in Boston, wrote a paper called "The Contagiousness of Puerperal Fever" which was first published in the *New England Quarterly Journal of Medicine* and subsequently reprinted in his *Medical Essays* in 1855 and in *The Harvard Classics* in 1910.

Child bearing is a normal physiological process. Through the ages a profession known as midwifery evolved. Midwives were trained in

[1] *"Je le pansay et Dieu le garist."*

a practical way, but seemed unable to cope with the unusual case requiring the use of forceps for withdrawal or that requiring version or version-extraction. Physicians became interested in the scientific implications in midwifery and Ambroise Paré, for example, invented the maneuver of *podalic version* when the child *in utero* was in such a position as to be unable to pass through the birth canal. Podalic version is simply the turning of the fetus around by grasping a foot and gently pulling it outward. Following this the Chamberlen family invented obstetrical forceps which were improved from time to time and have performed a valuable service to child-bearing women.[2] With these scientific improvements in technique the medical profession gained precedence over midwives. Unfortunately, the results of physicians in this line were not as satisfactory as were expected and many people still preferred midwives to physicians. One of the reasons for unsatisfactory results was the increasing number of deaths from childbed or puerperal fever, a disease developing shortly after the child was born in cases handled by physicians and not usually among those handled by midwives. Doctor Holmes in his essay maintained that puerperal fever was a private pestilence carried by the hands of the doctor. This brought a storm of protest from physicians, the majority of whom did not believe the thesis, maintaining with Dr. C. L. Meigs

[2] The Chamberlen family is famous in the history of midwifery as the inventors and perfecters of obstetrical forceps which are in general use today for the delivery of babies in difficult cases. The various members of the family kept the invention a secret through four generations and no one knows just which Chamberlen invented or improved the forceps. William Chamberlen, considered the founder of the family, was a French Huguenot physician who sought refuge in England in 1569. He had a large family and two of his sons, both named Peter and called Peter the elder and Peter the younger, studied medicine and attempted to control the practice of midwifery for their own financial benefit. In this they were not successful as the authorities would not co-operate. In the next generation another Peter, the son of Peter the younger, followed the same practices as his father and uncle but again the authorities would not co-operate. The third generation had three physicians Hugh, Paul, and John. Hugh managed to sell the secret of the forceps to a Dutchman named Roonhuysen who, in turn, sold it to the Medico-Pharmaceutical College of Amsterdam for a large sum of money. It is suspected that a certain amount of swindling took place as Hugh probably did not deliver all the secret to Roonhuysen and the Medico-Pharmaceutical College was unable to make forceps that would function properly. At any rate, bitterness developed among Dutch physicians who had bought these forceps and a public scandal resulted. Hugh Chamberlen of the fourth generation (1664-1728) finally gave the secret to the world and was posthumously rewarded by the Duke of Buckingham who caused Hugh Chamberlen's statue to be placed in Westminster Abbey.

that the disease was due to "accident or Providence." In Holmes' final paper he was able to quote the experiments and results of Dr. Ignatz Philipp Semmelweis (1818-65) of Vienna substantiating his original contention.

Semmelweis was a pioneer in the prevention of puerperal fever. He was an assistant in the first obstetrical ward of the Allgemeines Krankenhaus (General Hospital) of Vienna. He had performed many autopsies on young mothers who had died following the birth of their babies. A friend performing an autopsy on one such case accidentally pricked his finger and died of the same general type of disease. Semmelweis performed the autopsy on his friend and noted the similarity to the other cases. He concluded that a sepsis or an infection existed which was transferred to the pathologist who had died. This was in 1847, before bacteria or filtrable viruses were recognized as the causative agents which produced contagious disease.

In addition to the evidence at autopsy, Semmelweis also had clinical observations to support his view which was about the same as that of Holmes. The first obstetrical ward of the Vienna General Hospital was in the same building as the second but the latter was under midwife control while the former was staffed by physicians and medical students. Puerperal fever was very common in the first ward and rare in the second. The second ward was much more popular than the first because of the definitely lower death rate. It was consequently much more crowded. It is said that pregnant women begged, with tears, not to be taken to the first ward, for fear of death from puerperal fever. The atmospheric conditions were the same in both, if "miasms" were present in ward number one they should also be found in ward number two, just next door. Furthermore those cases admitted to ward number one who had given birth to their babies on the street, by accident, did very well, none of them developing puerperal fever. If "miasms" were the cause of the disease a proportionate number of these mothers should have developed puerperal fever.

Convinced of the contagiousness of puerperal fever, and noting that medical students came directly from the dissecting room or autopsy room to ward one and examined women without first washing their hands, Semmelweis ordered that all who came into the ward should first wash in a solution of chloride of lime. Deaths from puerperal fever stopped abruptly. Semmelweis became a crusader against

puerperal infection, but met with so much opposition that he eventually lost his mind and died in an insane asylum. His teachings and those of Holmes in this country were neglected to such an extent that puerperal fever continued to be a widespread disease. It was not until the discoveries of Pasteur and the early bacteriologists became known, that the question of puerperal fever, or, as it is now called, puerperal septicemia, was settled.

In 1861, Joseph Lister began his work at the Glasgow Infirmary. This work was to give rise to a new and different concept concerning disease. Semmelweis had been a voice crying in the wilderness. Lister was the real master who was to lead the scientific world from darkness to light. His first great discovery was that air had little or nothing to do with the infection of wounds. Reading a paper of Pasteur's published in 1862 [3] he came to the conclusion that infection was similar to fermentation and caused by a multiplication of bacteria in a wound. Lister's success depended upon his realization that these bacteria could be prevented from getting into a wound, and his setting about to prevent infection in surgery. Lister, like Semmelweis and Holmes, soon realized that the prevention of wound infection was largely a matter of extreme cleanliness on the part of workers and the destruction of microbes on the instruments and dressings. His success was phenomenal and modern surgery owes its usefulness and importance to the scientific discoveries and adaptations of Pasteur and Lister.

It soon became evident that infection in surgery was not very different from infection in other and spontaneous disease. Mankind was slow to realize that he himself was the principal vector of disease, and once realizing it he has been extremely careless about the dissemination of microbes.

Method of Dissemination of Microorganisms in Contact Infection: Microorganisms leave the body in all of its discharges. They come from the eye in conjunctivitis and trachoma; from the ear in otitis media; from the nose, throat, and mouth in the common cold, diphtheria, scarlet fever, influenza, measles, chickenpox, smallpox, etc.; from the urinary tract in venereal disease; from the skin in ringworm infection, smallpox, chickenpox, etc.; from the intestinal tract in cholera, typhoid fever, amebic dysentery, etc. These organisms vary

[3] "Mémoire sur les corpuscles organisés qui existant dans l'atmosphere," Louis Pasteur, *Annals de Chimie et de Physique,* 1862.

greatly in their ability to withstand the environment of the outside world. They are essentially aquatic in habit, and, except for those that produce spores or cysts, will die in a short time after drying.

The Transmission of Contact Infection: This takes place in a wide variety of ways according to the habits of people. By the same token much contact infection could be avoided by proper habits of prevention. In coughing, sneezing, and loud talking a spray of moist droplets comes from the respiratory tract of a patient to the air. Microorganisms may be readily inspired and thus gain entrance to a victim. It is believed that droplet infection is one of the common methods of transmission of contact disease. Transmission is usually direct although it may be indirect as well. Indirectly, contact infection may take place from the use of any article freshly contaminated by a patient with a communicable disease or a carrier. Besides inanimate objects, fingers of the patient or the contact are important agents of transmission.

So many diseases are so readily transmitted that they are acquired as a rule early in childhood and are miscalled children's diseases. If one escapes them in childhood he will usually contract them later. Generally they are less severe in the adult.

The Incubation Period: In all communicable disease a period elapses from the time of exposure to the disease until symptoms develop. This is called the incubation period. It is assumed that during this period pathogenic microorganisms are multiplying within the host until they have reached a sufficient number to produce symptoms. This period is usually different for each disease. For example, very long incubation periods are found in rabies, a month or more; variable periods in tetanus and tuberculosis; short periods, from a day to a week, in influenza, pneumonia, scarlet fever, diphtheria, cerebrospinal meningitis, septic sore throat, acute conjunctivitis, and gonorrhea; from ten days to two or three weeks in measles, mumps, chickenpox, smallpox, whooping cough, typhoid fever, and syphilis. In the control of communicable disease the incubation period is important because sometimes specific prophylactic measures may be instituted during this period and the disease be prevented. This is especially true in rabies, tetanus, diphtheria, smallpox, measles, scarlet fever, infantile paralysis, and whooping cough.

Duration of Communicability: This also varies considerably. The

duration of communicability is usually confined to the period when there are definite symptoms. Most diseases are not communicable in their incubation period. Notable exceptions to this occur in influenza, mumps, diphtheria, cerebrospinal meningitis, sometimes typhoid fever, and amebic dysentery. This may be due to failure in recognizing the disease in its earliest stage. Some diseases are transmissible after all symptoms have disappeared: *e.g.*, syphilis, gonorrhea, diphtheria, typhoid fever, amebic dysentery, and others (see Chapter 6, p. 110).

Diseases Spread by Contact Infection: Diseases spread by contact infection include a very long list of the most important communicable diseases: the common diseases of childhood (measles, mumps, chickenpox, whooping cough, German measles, smallpox, scarlet fever, cerebrospinal meningitis, diphtheria, etc.); the common respiratory diseases (the common cold, influenza, tuberculosis, pneumonia, etc.); some of the intestinal diseases or those spread through alvine discharges (amebic dysentery, typhoid fever); the venereal diseases (syphilis and gonorrhea).

Influenza: Influenza in its epidemic form is very different from the ordinary endemic disease. Epidemics break out with explosive violence; a reasonably large number of cases appear within a week or two. The disease seems to be of short duration; the fever and acute symptoms of headache, backache, and pains in the joints rarely last more than three days. The convalescence is usually rather slow requiring several weeks or months before the individual feels completely well. Some feel that they have never recovered from the effects of the severe pandemic form in 1918 and date the onset of their ill health from an attack of "flu."

Influenza like the common cold illustrates the limitations of science, for our knowledge of its cause, mode of spread, and methods of prevention is still unsatisfactory. Four viruses are known as causative agents and others are suspected. Consequently, preventive measures, such as isolation of the patient, quarantine of contacts, and the use of face masks have been disappointing. Immunization with Virus A and Virus B has not been successful as the immunity received is of short duration. Contrasting this with diphtheria and typhoid fever, where the knowledge concerning cause, mode of spread, and methods of prevention have resulted in a tremendous reduction of the number of cases (morbidity) and the death rate, one can readily realize the

importance of a relatively complete knowledge of any disease. Influenza is still a major health problem.

Tuberculosis: In contrast with the common cold and influenza our knowledge of tuberculosis has caused an appreciable reduction in its morbidity and mortality even though it is still a serious health problem. The death rate in the registration area of the United States in

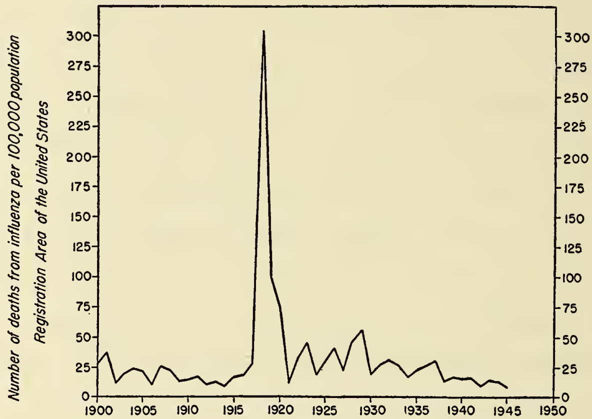

FIG. 39. Mortality from influenza. This disease in its endemic form is not so virulent as in its epidemic or pandemic form. In 1918 and 1919 influenza swept around the world. (See Fig. 24).

1946 was 36.4 per 100,000 of population. In 1900 the rate was 194.4. Bunyan called tuberculosis the "Captain of the Men of Death" because it was the principal cause of death in the seventeenth century. At present it stands eighth on the mortality tables and is preceded by heart disease, cancer, intracranial diseases of vascular origin, accidents, kidney disease, pneumonia, diseases peculiar to the first year of life (premature birth and similar conditions). It is estimated that it causes approximately 50,000 deaths a year in the United States and that the majority of these deaths occur in comparatively young people. It is the principal cause of death from 15 to 45 years of age.

Tuberculosis is a specific disease caused by the *Mycobacterium tuberculosis,* and characterized by a wasting away or "consumption." Its effects have been noted in the mummies of ancient Egypt and there

TUBERCULOSIS DEATH RATES

NUMBER OF DEATHS FROM TUBERCULOSIS PER 100,000 POPULATION

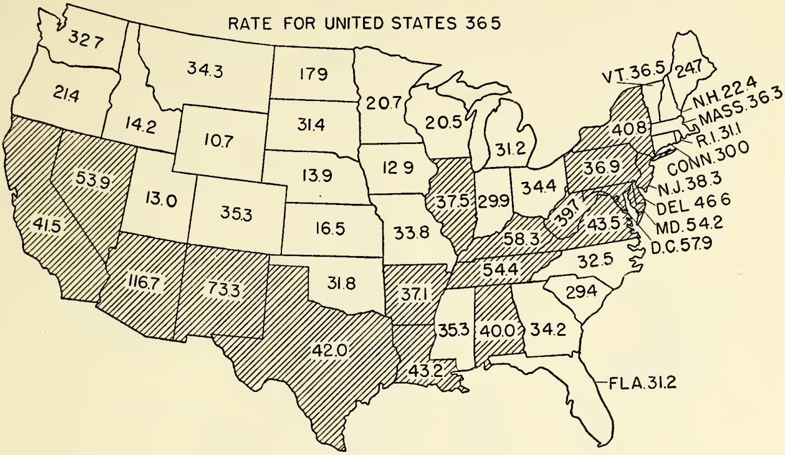

Fig. 40. Tuberculosis death rates are higher in some states (Texas, New Mexico, Arizona, Nevada, and California) due largely to the number of sanatoria located there for the treatment of tuberculosis. 1946.

REJECTION RATES FOR TUBERCULOSIS IN WORLD WAR II

NUMBER OF MEN REJECTED FOR TUBERCULOSIS PER 1,000 MEN EXAMINED

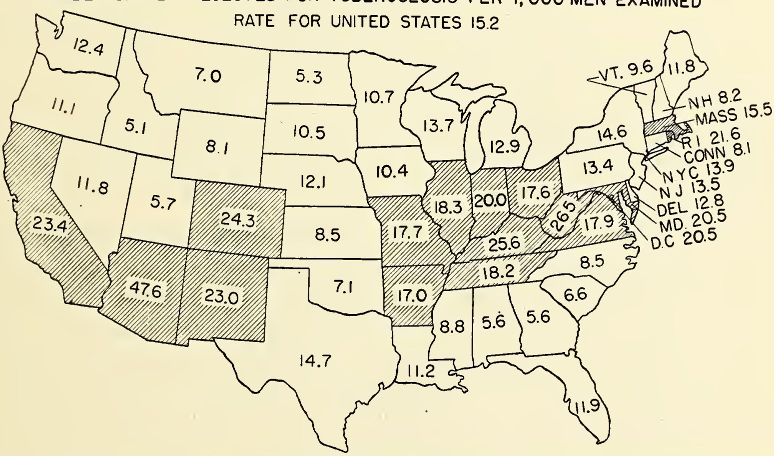

Fig. 41. These rates are for white registrants only. The rates for Negroes are somewhat lower. States in the shaded areas showed more than average incidence. April 1942 through March 1943.

Data from *Medical Statistics Bulletin No. 3*, National Headquarters, Selective Service System, Washington, D.C.

is every reason to believe it was prominent in the ancient and medieval world. All through history it has been no respecter of rank, wealth, or position. The rich and poor alike have been destroyed by its ravages. In the past many famous men and women have died of tuberculosis: Raphael, Molière, Samuel Johnson, Byron, Shelley,[4] Keats, Pope, Goethe, Voltaire, Kant, Emerson, Chopin, John Locke, Balzac, Kingsley, Ann, Emily, and Charlotte Bronte, Sidney Lanier, Robert Louis Stevenson, Ruskin, Heine, and many others. Doctor Samuel Johnson who had scrofula (tuberculous lymphadenitis) was "touched" by Queen Anne who revived the old method of so-called healing by the king's touch. Doctor Johnson's scrofula stayed with him but he was prone to think that Queen Anne gave him poor eyesight with her touch. In medieval times tuberculosis, especially of the lymph glands (scrofula), was called the King's Evil. Medieval kings had the idea that by touching the victim the disease could be cured. Philip I of France extensively practiced the king's touch in the eleventh century as did also Charles II of England much later. The futility of such practice ultimately caused the kings to abandon it.

It was not until the discoveries in physical diagnosis made by the musician and physician Leopold Auenbrugger (1722–1809) and the invention of the stethoscope by René Laennec (1781–1826) that comparatively early diagnosis of the disease was possible. After such early diagnosis and treatment according to the methods of Edward L. Trudeau (1848–1915) of Saranac Lake, New York, the death rate rapidly declined. The open air treatment of tuberculosis, however, did not originate with Trudeau for it was known to the ancients and neglected through the ages following.

A summary of our knowledge up to the present time would indicate that most cases of tuberculosis, diagnosed early, and treated with streptomycin, fresh air, good food, and rest will become "cured" or "arrested." Common methods of diagnosis include the tuberculin test, the X-ray, physical examination, and a sputum examination. In the event the sputum is negative for tuberculous organisms stomach washings of the patient may be examined for them. When only very small amounts of sputum are raised the patient usually swallows the microorganisms which may be recovered from the stomach. Such exami-

[4] Shelley, of course, was drowned but he had tuberculosis.

nation is only performed, however, when there is a strong suspicion that tuberculosis is present in the person being examined and the finding of the specific microbes is important. Other methods such as examination of the urine for tuberculosis of the kidney may also be used.

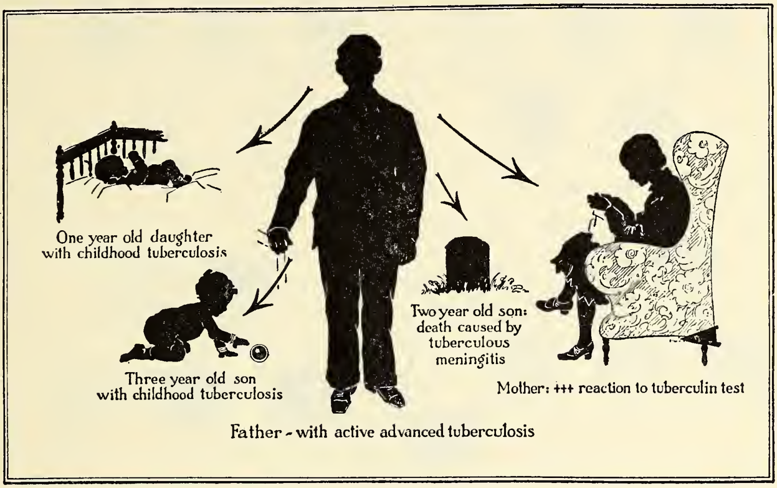

FIG. 42. Shows how tubercle bacilli have spread from the father to every member of the family.

Courtesy of Dr. J. Arthur Myers and the *Journal of the Outdoor Life*

Tuberculosis is a communicable disease usually transmitted to children by adults who are discharging tubercle bacilli in their sputum. The younger the child the more serious the results, when infected with tuberculosis. Conversely, if the individual is an adult when infected for the first time he is apt to have a rather benign form of tuberculosis. Children born and raised in a tuberculous family are very apt to die of that disease.

Clinicians now recognize two general forms of tuberculosis, the childhood type found more commonly at the tracheobronchial lymph nodes in the chest, and the adult type found more frequently at the apices of the lungs. The first infection is always of the childhood type even when contracted later in life and is practically symptomless. It extends into the lung tissue, destroying the latter and ultimately causing the death of the patient if not arrested.

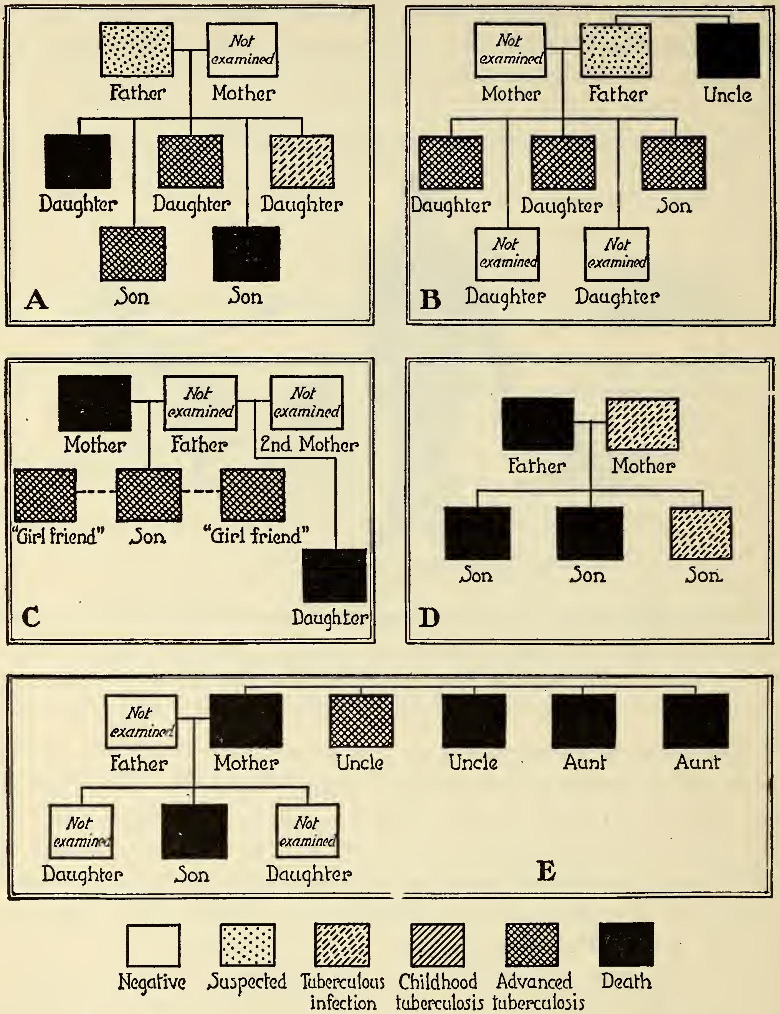

FIG. 43. Shows five families in which contact with the tubercle bacilli has spread the disease.

Courtesy of Dr. J. Arthur Myers and the *Journal of the Outdoor Life*

Tuberculosis of bovine origin has been practically obliterated. Dr. J. A. Myers of Minneapolis, one of the outstanding crusaders against tuberculosis, has called attention to the analogy between the human and bovine forms of this disease. Veterinarians have taught us all an important lesson in health promotion in their control of bovine tuberculosis (see Fig. 62). The slaughter of infected cattle is the keystone of their program. As Dr. Myers has pointed out, isolation will serve the same purpose among infected humans that slaughter does among infected cattle. If all the human cases could be isolated, tuberculosis would become an extinct disease. New cases always come from old ones who are discharging specific microbes in their sputum. Many of these cases could be successfully treated at home, if the patients' sputum could be made free of the specific organism by the operation known as pneumothorax (see glossary).

The tuberculin reaction indicates whether or not infection with the microorganism exists in a given subject. The X-ray examination shows the anatomical extent of the disease. Clinical examination with the stethoscope, temperature chart, etc., gives an idea of the degree of activity of the infection. An examination of the sputum for *Mycobacterium tuberculosis* will demonstrate the infectivity of the disease.

Efforts have been made to vaccinate children with attenuated bacteria (see chapter on Immunity) early in childhood. Over a million cases have been tried in Europe by the Calmette method with some success. Wholesale immunizations with attenuated bacteria (called BCG) have not been tried in this country except among medical students, nurses, and small children living in tuberculous families. As yet conclusive results have not been reported.

The Control of Tuberculosis: The disease tuberculosis is a special problem. Numerous experiments have shown that the tubercle bacillus is not like the ordinary bacterium. Highly specialized technique is necessary to grow the organism in the laboratory. Clinically the disease is quite different from others. It follows, naturally, that its control is a special problem in public health.

The first difficulty encountered is that there are no acute symptoms in the onset of the disease. The patient can, and usually does, continue his occupation for a long time before seeking professional advice. As a rule, when the patient is ill enough to call on a physician his case is moderately advanced or far advanced. An early diagnosis is

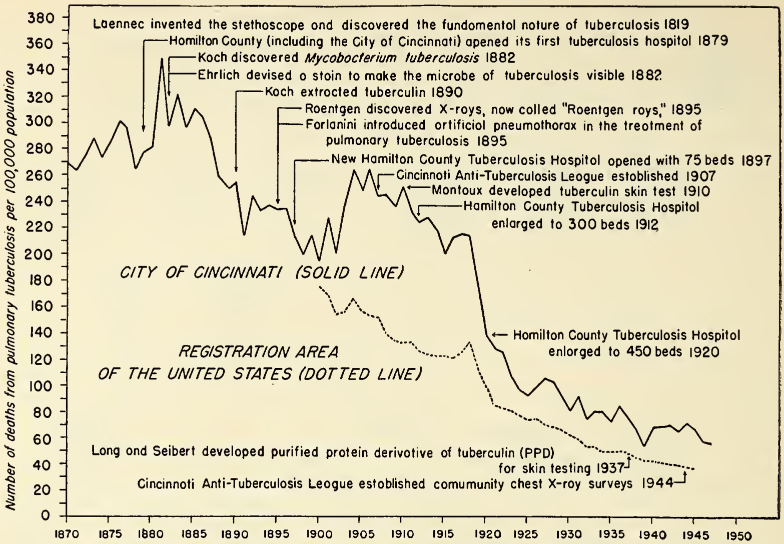

FIG. 44. Death rates from pulmonary tuberculosis in the City of Cincinnati and the Registration Area of the United States. An attempt is made to indicate the various factors which may have influenced these rates. All through the nineteenth century tuberculosis death rates were high throughout the civilized world. The nature of the disease was not understood until the time of Laennec who invented the stethoscope and made fundamental investigations in pulmonary tuberculosis. After the causative agent was discovered in 1882 the disease began to come under control. Ehrlich's method of staining the organism is still the standard and necessary procedure for finding this organism in the sputum of the tuberculous patient and establishing the diagnosis. The invention of tuberculin by Koch and its application to case finding by Calmette in 1907 and von Pirquet in the same year indicated that earlier diagnosis could be made. The tuberculin test commonly used at present is the intradermal injection of PPD and is a modification of the Mantoux test. The death rate for Cincinnati was influenced most by the building of the local tuberculosis hospital (now called the Dunham Hospital in honor of its first director) brought about by the agitation of the Cincinnati Anti-Tuberculosis League and the pressure this organization and the county medical society exerted on the City Council to build the hospital and the County Commissioners to enlarge it. The high death rate from 1901 to 1919, compared with the United States as a whole, was due to the influx of country people during the industrial development of the city and the unfortunate slums that resulted. The slums still exist but the tuberculosis situation is improved due to earlier diagnosis and better treatment.

Death rates for Cincinnati courtesy of the Board of Health of Cincinnati.

very rarely made except on a periodic health examination, and then only when special measures for detecting tuberculosis are followed. These special methods are X-ray examination of the lungs, and tuberculin testing (skin testing). Physical examination of the lungs with a stethoscope usually reveals only the advanced cases and not the beginning ones. Therefore, a periodic health examination, to be complete, should include an X-ray examination of the chest which incidentally gives the examiner information about the heart, lungs, spine, ribs, and other structures in the chest.

Each case is the source and fountain head for new ones, therefore efficient control is directed against the finding of all cases possible, and getting these under efficient modern treatment. It is the opinion of most specialists in tuberculosis that a case of the disease can best be treated in a well-equipped sanatorium. In the sanatorium the advanced procedures of pneumothorax, phrenicotomy, thoracoplasty, etc., can best be performed (see glossary). As a rule, the patient will not be discharged from the institution until his sputum is free from tubercle bacilli, and it is safe for him to go about in the community.

A practical procedure in case finding is to examine carefully all contacts with a new case. For example, if a student in college is discovered to have had tuberculosis, the following people should receive a physical examination, including an X-ray of the chest: the student's roommate, his fraternity brothers, his landlady, the servants in his living quarters, his personal friends, and everyone who has been associated with him to any great extent. In the case of an office worker the following should be examined and X-rayed: the whole family of the man, and especially his children; his servants; his fellow workers in the office; his personal friends or any of his relatives with whom he has associated very much. In the case of a workman, his family, all of the men working in his shop, his friends, etc., should receive the same kind of examination as outlined above.

There are a number of steps followed in the control of tuberculosis. Education is the most potent weapon, or at least is of primary importance. A growing consciousness of the presence of tuberculosis in the community depends upon the educational activities of health workers. The aim is to enlighten the public regarding the simple truths concerning the disease. The procedures followed are those used in any modern program of public education. They include articles in

the newspapers and magazines, bulletins through the mails to patrons of the tuberculosis seal sale, exhibits in public places, addresses over the radio, speeches made to organizations, use of movies and other forms of publicity work. The cooperation of the schools in the educational campaign is exceedingly important.

Case finding will always remain a vital measure in the control of tuberculosis. This is true because of the insidious nature of the disease, the difficulty of diagnosis in the early stages, and the importance of treatment as early as possible. Old cases serve as sources for new ones, therefore, upon diagnosis of each new case an investigation and examination should be made of all contacts.

Case finding among contacts, while important, does not solve the problem. Therefore the campaign to eradicate tuberculosis has been extended to the testing and examination of apparently well people. In this way unsuspected cases have been discovered. One method has been the testing of school children and other community groups by the use of the tuberculin skin test. (Mantoux test.) The patch test (Vollmer test) has been used for the same purpose. Those who give a negative reaction to the Mantoux test are assumed to be free from the infection. If the reaction is positive it does not mean the subject has active tuberculosis. It does mean that he has had the infection sometime in the past and that he may or may not now have active tuberculosis. To decide just what the present condition is in positive cases an X-ray examination is necessary. Therefore, all positive reactors should have a chest X-ray.

There are certain advantages and disadvantages in the use of the skin test as the first step for case finding in tuberculosis. Its principal advantage is mentioned below. Its disadvantages, although not serious as a rule, are somewhat troublesome, and disturbing. In the first place, skin testing is time consuming and laborious. If it is done correctly a number of procedures are necessary. Most health workers agree that the intradermal test of Mantoux is the most reliable, especially when the purified protein derivative of tuberculin is used as the testing material. This substance is called PPD and is injected into the skin of the forearm with a hypodermic syringe and needle. The dose of the first injection is 0.00002 milligram in 0.1 cc. of salt solution. If there is no reaction in 24 to 48 hours a second dose of 0.005 milligram of PPD is injected and again observed. A positive reaction (red-

ness and swelling of the skin at least 5 mm. in diameter) makes the second one unnecessary. To establish the fact that an individual has a negative tuberculin test he must be injected twice and observed at least twice. This requires at least three visits to a physician.

The injection of a relatively large amount of PPD on the second dose often causes a severe reaction with pain, swelling and sometimes ulcer formation at the site of the injection. In the latter case the physician making the injection feels alarmed; the subject thinks the doctor has bungled the job and may even threaten a law suit.

The more modern method of case finding is based upon the belief that everyone should have a periodic health examination and especially an X-ray of the chest. The aim is to examine as many people in the community as possible. Mass X-raying is done in schools, industries, and other groups where individuals are brought together. The work may be done by use of a portable machine which can be moved from place to place. The pictures are taken on a miniature film and enlarged for reading purposes. No disrobing is necessary and they may be taken at the rate of 150 per hour with ease. In one survey observed by the authors one machine took 360 pictures in a single hour. (University of Cincinnati, February 16, 1949.) Those who are screened out by this process as having an abnormal condition in the lungs or other organs of the chest have a full sized (14 x 17 inch stereoscopic films) picture taken which is used for more accurate diagnosis.

The use of X-ray alone in case finding has at least one disadvantage. In the Middle West there is a prevalent and usually benign disease, histoplasmosis, which causes confusion in the interpretations of X-ray films. Histoplasmosis produces lesions in the lungs which photograph very much like tuberculosis lesions. By comparison of Figures 40 and 41 it will be seen that the tuberculosis death rates in Ohio and Indiana were less than the national average in 1946, whereas the rejection rates for tuberculosis in World War II were greater than average for these two states. The explanation lies in the fact that the examiners for the armed forces were confused by findings on X-rays of selectees and diagnosed many cases of histoplasmosis as tuberculosis. There are other conditions in other locations which also confuse the picture. Known tests for these conditions are being used and new ones devised for the solution of this problem.

The advantage of tuberculin testing as a first procedure is evident

in this connection. If only positive reactors are X-rayed the field is narrowed considerably in the case finding of tuberculosis. Many tests are needed to diagnose tuberculosis in a given case and, in the last analysis, the finding of the specific organism in the sputum is still the criterion on which a definite diagnosis of tuberculosis rests.

The program must also provide for the follow-up of suspected and active cases and provision made for adequate care for not only the patient but the family as well when needed. Other measures include occupational therapy given while the patient is in the hospital and rehabilitation for those who will not be able to follow their usual occupations when discharged from the hospital.

The Common Cold: Very little is known about the common cold in spite of the fact that more people suffer from this disease or group of diseases than any other. If we could estimate the loss of time caused by the common cold, we should place it among the major diseases of mankind. Its principal importance lies in its tendency to cut down one's efficiency and to predispose to more serious disease. Most cases of pneumonia follow a severe cold in the head. Sometimes tuberculosis seems to be contracted in the same way. Many cases of head colds develop into a bronchitis with cough, the raising of sputum from the lungs, and more or less fever. There are certain facts concerning colds which seem to be well recognized.

1. It is believed from every day evidence that colds are infectious, but no one has demonstrated a specific organism producing them. Various types of organisms may be recovered from the nose and mouth of patients with colds: streptococci, diplococci, bacilli, and filtrable viruses. Evidence would seem to indicate that infection in the common cold is very complex and that visible bacteria and filtrable viruses are both necessary to its development. It is well established that the common cold is a group of diseases and not a single condition.

2. Every morbidity study made indicates that colds are more prevalent in the winter and spring than in the summer and fall. This would seem to indicate that our method of living in the winter has something to do with the susceptibility to colds. Just what this difference is can only be surmised. Several facts seem evident whether they have a bearing on the problem or not: (a) In winter, man remains indoors for a large part of the time, and is therefore in closer contact with his neighbors. He breathes a different kind of air, artificially

heated, often too dry, and usually polluted with microorganisms. (b) He wears different clothing, often too heavy, and always of a warmer nature than in summer. We have reason to believe that overclothing predisposes to colds. (c) Our diet is usually different in the winter,

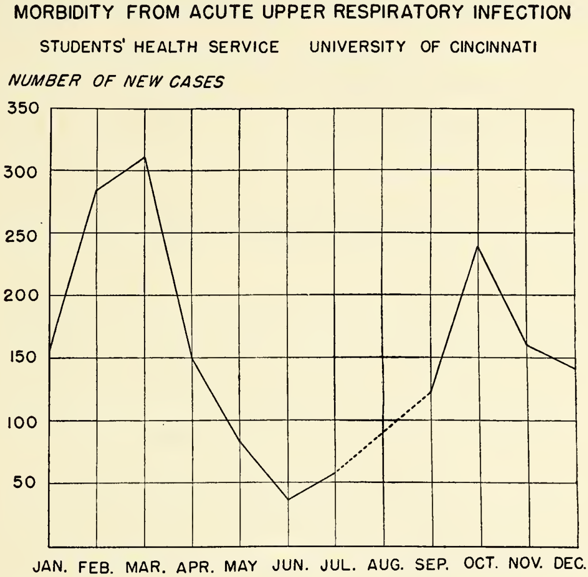

FIG. 45. This chart shows the seasonal prevalence of acute upper respiratory infections (colds.) Outbreaks in October are caused by infection of susceptible students returning to college after a vacation where they have not been in close contact such as occurs in the classroom, dining halls, etc. Outbreaks in February and March seems to bear marked relation to the weather. These months are particularly rainy, cold, and foggy in Cincinnati.

having less fresh vegetables and fruit in it. Undoubtedly the diet plays an important part in colds. (d) Because one lives indoors during the winter months he does not absorb enough ultra-violet light. In some cities during the winter the ultra-violet light is filtered out of daylight by the smoke pall that hangs over them. Leaving out the possibility that anatomical distortions of the nose predispose to colds, it is believed that those who are susceptible to them should take the following precautions: (a) Get as much outdoor life as possible in the

wintertime, avoiding over-exposure. (b) Do not overclothe the body, especially with heavy woolen underwear. A heavy overcoat for the outside in winter, with light underwear for indoor living is a better hygienic precaution. (c) Be very careful of the diet, getting as much fresh fruit and vegetables as possible. (d) Get some exposure to the sun whenever possible; when not possible get artificial ultra-violet light exposures under the direction of a physician. (e) Take vitamins or cod-liver oil on prescription of a physician if cold susceptible. (f) Develop rational personal habits with regard to sleep, work, and recreation.

The value of vaccines for the common cold has not been proven. The medical literature on the subject is voluminous and inconclusive. Until certain facts are definitely established the use of such vaccines is not recommended.

Syphilis: There is very strong evidence for the belief that syphilis was an endemic disease among the aborigines of the western hemisphere and was carried to Europe by the sailors of Columbus after his return to Spain from Haiti in 1493. History has recorded its rapid spread over Europe and all parts of the civilized world. The history of this disease is very instructive from a hygienic point of view for it demonstrates how vicious a communicable disease can become when transplanted to virgin soil. The people of Europe had no natural nor acquired immunity against it. It was therefore much more destructive to white men in Europe than it had been to red men in America. It is also of interest to note that because of mankind's restlessness and desire for travel this disease as well as most others has been carried to every spot in the world. According to Stokes [5] its nature has changed so that instead of "killing a man alive on the street, syphilis has taken to knifing him quietly in his bed." Its ravages were greatest in the sixteenth century, but it is endemic and prevalent today, so much so that it should be carefully studied by everyone as one of the major social and hygienic problems of the age.

The first problem in the control of syphilis is to realize that it is not necessarily a venereal disease and the second, to spread among people the idea that the man who has it may not necessarily have sinned to get it. Syphilis should be thought of as a disease and not as

[5] Stokes, John H. *The Third Great Plague*, Philadelphia, W. B. Saunders Co., 1917.

a disgrace. At least half of the victims of syphilis, if not more, are innocent of any illicit sexual relations. A father may have contracted syphilis and infected his whole family; his wife by contact, and she in turn their children while they were in the embryonic stage. Widespread instruction as to the cause, mode of transmission, prevention, and treatment must precede any particular advance which may be hoped for.

Syphilis should be thought of as a serious general disease caused by the *Treponema pallidum* which is at first local but soon becomes general, and may affect almost any organ or tissue of the body. It is considered to be curable although sometimes relapses occur in those thought to have received adequate treatment.

Syphilis has been divided into three principal stages: the primary, secondary, and tertiary stages. The primary stage is characterized by a local sore and extends in time traditionally, until the appearance of a rash on the skin, which is termed the secondary stage. The tertiary stage is characterized by the invasion of some organ such as the heart, brain, or spinal cord. The germ of syphilis is of interest and importance for it presents many peculiarities. It is pale in color, very difficult to see under the microscope, and hence is called the *Treponema pallidum.* In order to see it the field of the microscope must be made dark and the germ appears as a fine light corkscrew-like organism. Fortunately it is very frail and dies when dried or when treated even with mild antiseptics. Exposure to the air and sunshine kills it in a short time, and inanimate objects are not likely to carry it from person to person unless it is kept moist and promptly transferred. For example it is conceivable that a person with syphilitic lesions of the mouth might deposit *Treponema pallidum* on a common drinking cup and the same organism be deposited on the lip of the next drinker using the cup. Instances of this kind have been known.

The germ gains entrance to the body through a break in the skin or mucous membrane. This break may be microscopic in size, therefore one cannot be certain after exposure that he will not develop the disease even though his skin seems whole. The usual sites of the primary lesion or chancre are at the entrance of the germ on the glans penis in the male, on the labia majora or minora in the female, or at the muco-cutaneous border of the lip, or even on the fingers. Other parts of the body may be attacked. The chancre may be so small as to

escape the notice of the patient or may grow to a considerable size. It may be within the urethra or the vagina. It may be, but usually is not, painful, does not itch, and usually has a hard indurated base.

The diagnosis of chancre depends upon finding the *Treponema pallidum* in excretions from the chancre by means of the dark field microscope. This should be done before any treatment either local

FIG. 46. Chancre of the lip. The primary stage of syphilis.
Courtesy of Dr. Daniel J. Kindel, Cincinnati

or general is used. The patient is carefully examined as well for enlarged lymph glands in the neighborhood (the groin when the chancre is on the genitals). A swelling of the lymph glands from syphilis usually lasts about two weeks.

After a varying length of time the germs are more or less suddenly distributed from the region of the primary sore throughout the blood stream and to all parts of the body. This marks the beginning of the second stage. Skin lesions usually characterize this stage, the patient experiencing a definite rash. The skin however is not the only organ affected and the patient usually has definite subjective symptoms such as a sore throat, rheumatic pains in the joints, slight loss of weight and strength, and other constitutional symptoms. *The rash gradually disappears* whether treated or not. Any *chronic* skin rash which a per-

son may have is likely *not* to be syphilis. Some people suffer from a variety of unsightly skin lesions especially acne, psoriasis, and ringworm. They are of a very chronic nature and should not be confused with syphilis which is more *acute* when found in the skin.

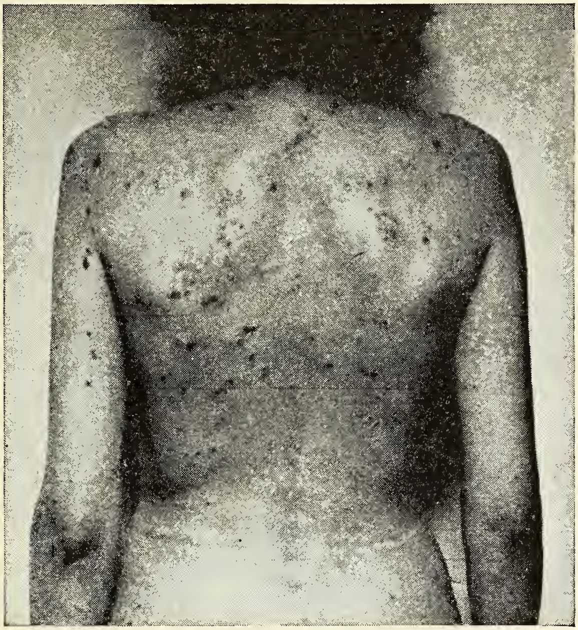

FIG. 47. A syphilitic rash. The secondary stage of syphilis.
Courtesy of Dr. Daniel J. Kindel, Cincinnati

Sometimes frequent relapses occur which make the patient a real menace to his family and the community. At this stage there are grayish white patches which appear on the mucous membranes everywhere. These "mucous patches" as they are called, contain the germs of syphilis in large numbers and occur in the mouth particularly. Here the germs may be easily transferred to another by means of kissing or the common drinking cup. Vigorous treatment according to modern standards will soon render the patient harmless, and from a hygienic point of view should be insisted upon.

The tertiary stage is the most serious from the standpoint of the patient. Usually this is prolonged but sometimes it merges with the

secondary stage and comes on within a few months of the appearance of the chancre. The outstanding development in tertiary syphilis is the *gumma,* a tumor-like swelling in some tissue of the body. The tissue attacked by a gumma is destroyed and eventually replaced with scar tissue. In this way a gumma destroys an organ and often leads to the death of the patient. When it attacks a large blood vessel, a

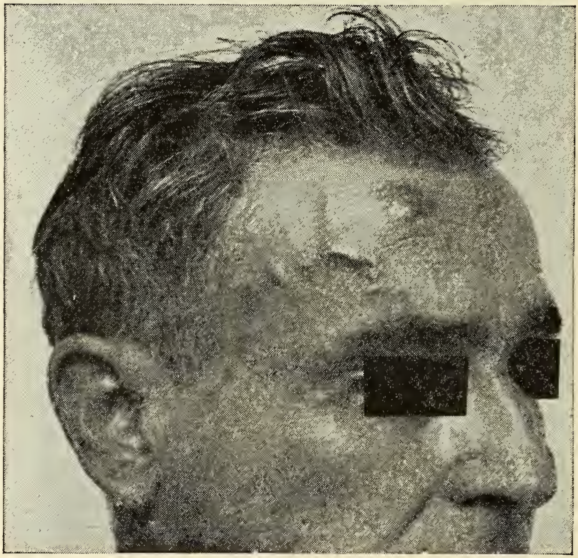

Fig. 48. Annular syphilis of the right temporal region. This is a ring-like lesion and one of the forms of the tertiary stage of syphilis.

Courtesy of Dr. Daniel J. Kindel, Cincinnati

weakening of the wall results (*aneurism*) which ultimately causes a rupture to occur in the blood vessel and the sudden death of the patient from internal hemorrhage. The bones of the nose may be eaten away and the nose collapse, forming the so-called "saddle nose" or a nose without a bridge. If the valves of the heart are destroyed the victim's time for life is short. But more pathetic than all are the effects of syphilis on the nervous system. The two outstanding forms of the disease here are locomotor ataxia (*tabes dorsalis*) and general paralysis of the insane (general paresis). In the former case the *Tre-*

ponema pallidum has attacked the lower part of the ascending dorsal fibers of the spinal cord and destroyed them. They are replaced with scar tissue which obviously has no nervous function. In the latter case the actual structure of the brain has undergone a similar change resulting in a mental derangement or psychosis. Taboparesis which is a combination of the two is not uncommon.

Locomotor ataxia usually begins in the feet and legs and travels upwards. The patient loses control of his feet; he cannot walk unless he is looking directly where he steps. Sometimes his first experience is that of falling in the dark, or in the bathroom where he is washing his face. He feels as though he were walking on cotton. When lying in bed he cannot localize his feet and "loses them in bed" as it were. Later on he suffers severe pains in the abdomen (gastric crises) with vomiting, girdle-like sensation here, loss of control of the bladder and rectum (incontinence of urine and feces) as well as many vague and obscure symptoms.

Paresis is a progressive mental deterioration of the most distressing kind. The patient gradually becomes completely demented, paralyzed, and ultimately dies. He must be put into a sanatorium from the start in order to protect society. Because of his lack of judgment and his grandiose ideas he usually wrecks his family financially. He may even commit a homicide or some other crime for no apparent reason.

An appreciable amount of paresis still exists. In spite of widespread and even free medical treatment of syphilis, individuals allow the disease to progress until it reaches the brain and does irreparable damage. A steady stream of paretics come to mental disease hospitals every year. Many of these cases are now treated successfully by the injection of malarial parasites *(Plasmodium vivax)* into the blood of the patient and allowing the infection thus induced to run a long course. It is a well-established fact that malaria is antagonistic to syphilis and may cause the arrest of the latter disease. Because the fever is usually very high in most cases of malaria it is believed that the high fever is the principal factor in this treatment. (The fever in malaria may reach as high as 107° F.) "Fever machines" have been devised for the treatment of paresis but certain difficulties have been encountered in their use. It is difficult to raise the body temperature to the desired point without some danger. Also burns are common in the use of such machines and expert technicians are required for their operation.

There is a scarcity of such technicians. The malarial treatment of syphilis is the most popular and most widely used.

The Wasserman test for syphilis has been used since 1904 to help in the diagnosis of this disease. It is called technically a complement fixation test and is difficult or impossible to explain in a few words. In modern practice improvements on the original test are used, as a rule. These other complement fixation tests are called the Kolmer and the Hecht-Gradwohl tests.

The Kahn test for syphilis is simpler and employs only the subject's blood serum and a substance usually obtained ready-prepared from a biological supply company. A positive test is indicated by a flocculation when the materials are mixed together in certain dilutions and shaken for three minutes.

Other tests for syphilis are the Kline precipitation test, the Ide test, the Eagle flocculation test, and the Hinton glycerol-cholesterol test.

Unfortunately the various tests for syphilis are not absolutely reliable and accurate. There are occasional "false positive reactions" encountered. On the other hand, when syphilis has reached the central nervous system the blood test is often negative but the test for syphilis applied to the spinal fluid is usually positive. In neuro-syphilis other tests are commonly employed, *e.g.,* the colloidal gold test.

Adequate treatment consists in having a competent physician administer arsenic preparations similar to salvarsan, or penicillin, or both and continue these treatments until, in the judgment of this expert, the case is cured. Compounds of bismuth and other drugs are also used. The curability of the disease is in some doubt, but it is believed that the great majority of the cases are cured by modern treatment properly performed. Treatment should be begun in the primary stage.

A child who is born with syphilis in either active or latent form is a greater or less menace to others, varying with the degree of activity of the disease. The syphilitic child is usually under par physically and is often the victim of some intercurrent infection which takes it off. If the baby survives it usually suffers from degenerative changes similar to those the person with acquired syphilis experiences but these pathological changes come on early in life. Interstitial keratitis ultimately leading to blindness if uninterrupted, and degeneration of the eighth cranial nerve leading to deafness may be two of the important

complications. This makes the victim a charge on society in the majority of the cases. In prenatal clinics it is considered best practice to subject the blood of all prospective mothers to the Wassermann test. Those showing a positive reaction should be vigorously treated in the hope of preventing the extension of the disease to the unborn baby. Miscarriages are the rule, however, in syphilitic pregnant women, and normal births the exception. If a baby be born with unmistakable signs of syphilis it should be thoroughly treated from the start, even though the congenital type be less amenable to treatment than the acquired form. Institutional treatment is usually necessary.

In cases where a woman's child has died and she is available as a wet nurse great care should be exercised to be certain that she is free from syphilis as well as other diseases. One should be suspicious of the health of the mother of a stillborn child and be doubly certain in such a case that no syphilis is present.

Syphilis being transmitted only in the primary and secondary stages and then only from open lesions, discharges from which contain the germs, the prevention of the disease should be a fairly simple matter. Such is not the case however, and it is a sad commentary on the looseness and promiscuity of mankind in its intimate relations that this is true. One reason for the widespread prevalence of the disease is that the lesions are usually painless or even symptomless and the ignorant patient spreads the disease often without knowing that he has it. The most important element in the spread of the disease is close personal association.

Theoretically, inanimate objects may carry it if they are handled or used by the susceptible individual just after having been used by a syphilitic patient. Thorough washing with hot water and soap suds undoubtedly renders all dishes clean, on the other hand, cold rinsing of glasses at an ordinary soda fountain probably does not. The common towel is another danger which is being realized and prohibited by law in many places. To those who have seen a great deal of syphilis the consensus of opinion seems to be that these are the common modes of getting the infection:

1. Promiscuous sexual intercourse.
2. Dentists, physicians, and nurses examining or treating syphilitics.
3. Kissing.
4. The common drinking cup and roller towel.

The prevention consists in the following:

1. The elimination of licensed prostitution. This does not stamp out the disease but brings about a great reduction in its incidence. It is a mistaken idea that by having a red light district venereal disease may be better controlled. Actual experience has been to the contrary.

2. The isolation and compulsory treatment of all cases, preferably in a hospital. This can only be accomplished by a fearless health department compelling the reporting of cases and their isolation.

3. Widespread education as to the cause, nature of the disease, modes of transmission, and competent treatment of those infected. In many states young people about to be married are required to have a medical examination and a Wassermann test made before marriage. The presence of syphilis in either party may require postponement of the marriage and intensive treatment of the patient until non-infectious.

4. Personal prophylaxis although not certain in its results has greatly reduced the incidence of the disease in the United States Army.

5. The prevention of prenatal syphilis may be accomplished by blood testing the mother early in pregnancy and intensively treating her at once.

Gonorrhea: This is a contact disease of wide distribution. It has been recognized for centuries and its symptoms described in ancient writings. Neisser discovered the specific microörganism, *Niesseria gonorrheae,* in 1879. It has little vitality outside the human body but inside it will live for years. Gonorrhea is one of the most widespread of contact infections. The transmission is usually by sexual intercourse and the prostitute is the common carrier.

The disease is characterized by a purulent discharge of the organ or part affected, the urethra, vagina, or conjunctiva of the eye. Other parts of the body are invaded by direct extension or by the blood stream. Infection of the joints or the lining of the heart occurs in some cases by blood-stream invasion. It is far from a trivial infection as permanent invalidism is not uncommon in many cases.

Gonorrhea was one of the first diseases to be treated by the sulfonamide drugs. At first it responded well and many cases were cured. Then sulfa-resistant strains of the organism developed and the drugs were ineffective in many cases. Following this physicians used penicillin in treatment which, at first, was very effective. Now many penicillin-resistant strains of the microbe have developed and this drug is no longer the panacea that it was thought to be.

In theory the elimination of gonorrhea should be a simple matter. In practice it is very difficult. The measures suggested above for the

prevention of syphilis apply, for the most part, to this disease. Refraining from illicit sexual intercourse is the key to the solution of the problem.

Acute Anterior Poliomyelitis: This common and epidemic disease is caused by a filtrable virus which attacks the anterior horn cells of the spinal cord and other cells in the central nervous system. Its exact mode of transmission is not now known. It may be water-borne, as many cases are contracted at bathing beaches and after swimming. It may be insect-borne as epidemics follow the fly season in incidence of cases. However, most observers feel that it is a contact infection.

Poliomyelitis is a discouraging public health problem which is being studied intensively by clinicians, public health workers, bacteriologists, and others interested in the solution of the problem. Investigators have been studying the disease in the patient, the virus in the laboratory, and modes of transmission in contacts. The investigations have been carried out in communities large and small. About the only thing that has been learned is that the disease and its transmission does not follow any of the well-recognized patterns for other and similar conditions. The solution of the problem is therefore not at hand.

Common Communicable Diseases: Common communicable diseases transmitted by contact infection are measles, German measles, mumps, scarlet fever, diphtheria, and a few others not well recognized at present. They are so contagious that they are usually acquired in childhood and hence called childhood diseases. All of them are reportable to the local health officer together with many of those mentioned in the preceding pages.

Other Common Contact Diseases: Those conditions not mentioned above which are thought to be transmitted by contact infection together with their cause are the following:

Coccidioidomycosis, sometimes called "desert fever," is caused by *Coccidioides immitis* and was mentioned on page 47.

Erysipelas, a skin disease of infants and sometimes elderly people, is caused by the *Streptococcus erysipelatis*.

Leprosy is caused by the *Mycobacterium leprae*.

Meningitis is caused by a number of organisms and hence is a group of conditions and not a single specific disease. It may be caused by the filtrable virus of mumps. In epidemic form it is usually caused

by the *Neisseria intracellularis.* Other forms are caused by *Diplococcus pneumoniae, Hemophilus influenzae, Mycobacterium tuberculosis,* the *Staphylococci,* the *Streptococci,* the *Treponema pallidum,* and others. The disease is an infection of the meninges or coverings of the brain and spinal cord.

Pneumonia is also a group of diseases and may be caused by *Diplococcus pneumoniae, Pasteurella pestis, Klebsiella pneumoniae, Mycobacterium tuberculosis,* the *Stretococci,* filtrable viruses and others.

Rheumatic fever, the cause of which is unknown, usually follows an acute infection by certain hemolytic streptococci.

Vincent's infection, which is a specific disease caused by the *Borrelia vincentii* and *Fusiformis dentium* growing together, is popularly called "trench mouth."

Encephalitis is also a group of diseases caused mostly by filtrable viruses but microorganisms are sometimes seen in certain cases.

Infectious mononucleosis is caused by a filtrable virus.

Smallpox is an infection caused by a filtrable virus.

Infectious hepatitis is caused by a filtrable virus.

Impetigo is a skin disease of uncertain cause.

Ringworm is caused by a group of fungi.

In addition to the diseases mentioned in this chapter there are still others transmitted by contact infection.

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(*Note:* Most of the references given at the end of Chapter 3 also apply here.)

6

DISEASES SPREAD BY THE HUMAN CARRIER

Probably more diseases are spread by the human carrier than is now realized. Unquestionably gonorrhea, syphilis, hookworm, typhoid fever, cholera, amebic dysentery, diphtheria, cerebrospinal meningitis, malaria, influenza, and pneumonia are often transmitted to the healthy by the "carrier." A carrier is a person who, without symptoms of a communicable disease, harbors and disseminates the specific microorganisms. A number of descriptive terms have been applied to these people. For example, a person who harbors the germs of a disease and is in the incubation period of the disease is called an "incubatory carrier." A person who harbors and disseminates a microorganism, and who has never had the disease (in other words is "healthy") is sometimes called a "healthy carrier." This term is not as good as "passive carrier" for there is some question as to just what constitutes a "healthy" person under such circumstances. "Convalescent carriers" are those who harbor and disseminate microorganisms after an attack of disease. Convalescent and passive carriers are further spoken of as "acute," "transitory," or "temporary" when they are carriers for a shorter period of time, and "chronic" or "permanent" when they are carriers for years or indefinitely.

Many tissues of the body may harbor specific microorganisms capable of producing disease. For example, the blood may harbor the germs of syphilis, malaria, and a number of tropical diseases without producing any symptoms in the individual. In the matter of syphilis the transmission is usually congenital, and usually from mother to child, yet cases have been known where infection of the susceptible individual has accidentally taken place in drawing blood for a Wassermann test. Malaria requires an insect host for transmission (see Chap. 12) as do most of the tropical diseases of this nature.

The urinary tract may harbor the germs of gonorrhea, and the in-

dividual harboring such germs may be free from symptoms, and yet be able to transmit the disease readily. This explains the enormous prevalence of gonorrhea, for no sane person would expose himself to the disease with one who has symptoms. These carriers are sometimes called "urinary carriers."

"Oral carriers" are those who carry pathogenic bacteria in their mouths or adjacent parts. The common carriers of this kind usually transmit diphtheria, influenza, pneumonia, cerebrospinal meningitis, and probably a number of other conditions, such as scarlet fever, whooping cough, measles, and others.

"Intestinal carriers" are those who carry typhoid fever, Asiatic cholera, amebic dysentery, hookworm, and other intestinal diseases. Typhoid fever was one of the first diseases discovered to be transmitted by carriers. Many severe epidemics have been caused in this manner in the past when typhoid was more common than it is now.

The carriers who have come under observation to the greatest extent are typhoid, diphtheria, and amebic dysentery carriers. In fact, most attention seems to have been directed along the line of these diseases, probably because such carriers can be demonstrated so easily. It must be true, however, that there are many more carriers than we can readily detect.

The control of carriers is much more difficult than their detection. There is a question about how much isolation the state can enforce. It is not sufficient to pass sanitary codes and leave to the individual the practice of these codes. It has been too frequently the custom to label a person who shows diphtheria organisms in his throat as a carrier and attempt to isolate him. Experience has shown that carriers often wander away from their places of detention and are lost sight of thereafter. The whole carrier problem is of major importance in public health practice.

The first question which naturally arises in the case of a carrier is whether or not the individual harbors virulent organisms. A virulence test is made by injecting susceptible animals with the organism and determining the degree of virulence for the particular animal tested. This unfortunately gives only a rough idea of the virulence as far as man is concerned.

The next question is how can the public be protected? This is one of the most difficult of public health problems. The carrier may be

isolated, but it is very difficult for the state to provide for the indefinite residence of all carriers for the rest of their lives. In the first place their number is probably large. Then again there are legal problems involved. It is very difficult to prove that a certain individual is a carrier. Organisms may be isolated from him, and may produce disease in a laboratory animal. Would these organisms also produce disease in the human? Such experiments cannot be tried. Every first- or second-year medical student has performed the following simple experiment. A rabbit is injected with the sputum of a normal and healthy person, usually the student himself. In the majority of cases the rabit will die of septicemia, and various organisms can be recovered from the rabbit. If almost any individual may be able to kill a rabbit with his sputum, does this make almost any individual a carrier?

It has been pointed out a number of times since the time of Pasteur that virulence varies with the type of resistance it meets. The most virulent germs are those coming directly from a patient. The next most virulent germs are those coming from a healthy person who has become a carrier because of contact with a case. The carrier who has obtained his organisms from another carrier is harboring less virulent germs than either the case or the contact with a case.

The whole question of carriers is still very much unsettled. This much seems to be evident, that it is possible for a carrier, especially of some diseases, to live with other people and not infect a healthy person, if he is careful. The typhoid fever carrier does not transmit that disease unless he handles food consumed by others. Diphtheria carriers could and do go about in the community without producing epidemics of the disease if they are taught to protect others. One of the principal types of carrier is the prostitute with chronic gonorrhea. The malaria carrier is largely responsible for the widespread character of malaria.

Amebic Dysentery: This has usually been considered a rare disease except in the tropics, but during the Century of Progress Exposition held in Chicago in 1933 a number of cases developed among employees and guests at several hotels in Chicago where chronic carriers were employed as food handlers. The cases came to the attention of authorities in August. By that time the disease had spread to other cities and received widespread publicity in the daily and weekly press.

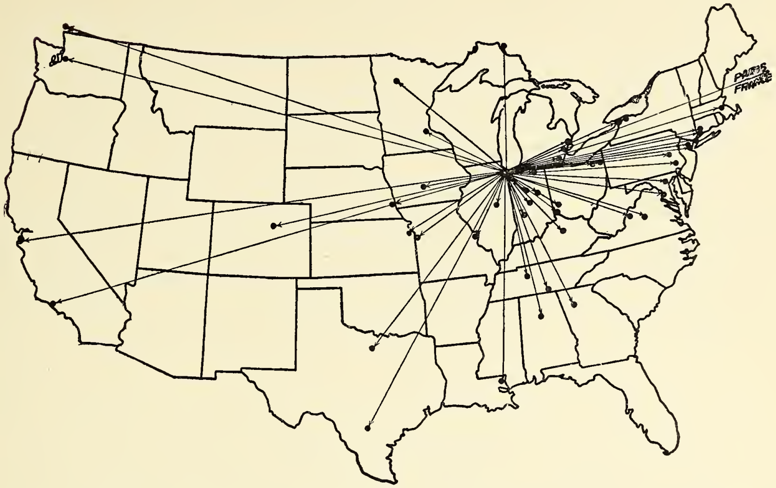

FIG. 49. The spread of amebic dysentery from Chicago in the summer of 1933. Known cases up to November 14, 1933. Here is a possibility of over fifty new foci for the spread of amebic dysentery, essentially a carrier disease.

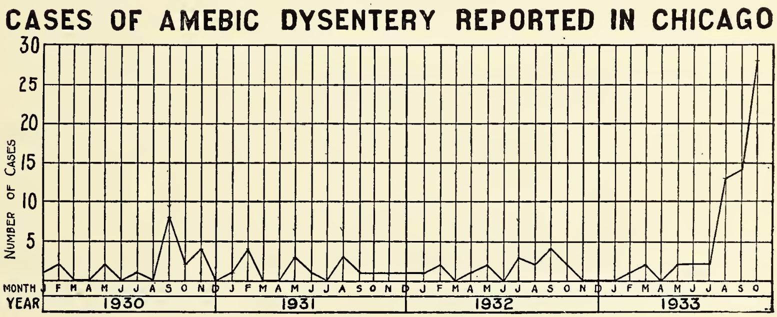

FIG. 50. The number of cases of amebic dysentery reported by physicians to the Chicago Health Department. This chart illustrates the importance of prompt and universal reporting of communicable disease. The Chicago Health Department did not realize that an epidemic existed until August. Meanwhile the disease had spread over the United States (see Fig. 49 and text).

Dr. Herman N. Bundeson and others have reported this epidemic[1] and the figures quoted here are taken from their article. It seems that amebic dysentery is endemic in most localities in the United States but is not sufficiently severe to produce symptoms or to be definitely recognized. The diagnosis is made by stool examinations, a procedure not often carried on routinely in medical examinations. However when surveys are made an appreciable number of apparently normal people are found to be infested with the *Endameba histolytica,* the causative agent of this disease. The health authorities of Chicago did not become aware of the presence of an epidemic until August 15, 1933, when two cases of amebic dysentery were reported to the Health Department. These cases gave a history of having eaten at a certain Chicago hotel some time previously. A staff was sent to this hotel to examine the food handlers and 13 cases af amebic dysentery were discovered among them. Measures were taken to isolate and treat the cases, and stringent sanitation observed. Repeated examinations showed an ever increasing number of employees of the hotel, those who handled food and those who did not, who were harboring the organism. Up to November, 1933, Chicago had had 19 deaths from this disease, 185 cases, and 193 discovered carriers. The incubation period of this epidemic varied from 9 to 95 days, and cases spread from Chicago all over the United States (see Fig. 49), and many people became ill after they returned to their homes. A questionnaire was sent out to the guests of the hotel involved and 69 positive cases of dysentery were discovered, with the possibility of more that had remained unrecognized. Methods of diagnosis and control were given wide publicity. Ultimately it was discovered that several hotels in Chicago had antiquated plumbing fixtures, especially toilet bowls, which, when flushed, siphoned water from the bowls into the supply pipes from which drinking water was obtained. Amebae from the feces of carriers were thus spread widely through the plumbing system of these hotels and infected the guests.

Protecting the Public against Carriers: Many efforts have been made to cure carriers of their condition. Success has attended some of the efforts, failure others. The problems involved are mainly clinical and call for concerted action from all types of medical men.

[1] Bundeson, Herman N., Rawlings, Isaac D., and Fishbein, William I. "The Health Hazard of Amebic Dysentery." *Journal of the American Medical Association,* v. 101, p. 1636, 1934.

Urinary carriers require treatment by genito-urinary surgeons. These specialists have been successful for most part in clearing the cases who are faithful in following treatment. Chronic venereal carriers usually require institutional medical treatment, which consists in local applications of disinfectants, the use of certain vaccines, physiotherapy, antibiotics, and surgery. Attempts to cure urinary typhoid carriers have been on the whole unsuccessful.

Most typhoid fever carriers whose organisms are multiplying in their gall bladders can be freed of these microorganisms in their stools by the surgical removal of the gall bladders. In Massachusetts there is a record of about 93 per cent cures by this method. There have been no reports of success by the use of drugs or antibiotics in typhoid carriers.[2]

Some states have offered a money reward to typhoid carriers if they pledge themselves not to handle food intended for other people. This procedure has proven costly and for most part unsatisfactory. Instead of following this course the state of Massachusetts is paying the cost of the surgical removal of gall bladders in those cases where the typhoid bacilli are definitely proven to be multiplying in the gall bladder.

Diphtheria carriers have presented another public health problem of the most difficult kind. The organisms of diphtheria live in the nose and throat. Numerous attempts to cure these carriers by removal of tonsils have been only partially successful. All varieties of disinfectants have been tried in the past mostly without success. Perhaps the most promising treatment has been that of the local use of penicillin in the form of lozenges and nasal spray.[3]

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7

DISEASES USUALLY CONTRACTED FROM THE SOIL

Nature and Function of the Soil: The soil is the upper layer of the earth's crust, and is formed from the disintegration of rocks and the decay of animal and vegetable matter of all kinds. Just below the soil is the subsoil which varies from a few feet to hundreds of feet in depth, to hard pan or impermeable stratum. The soil teems with life, especially its upper layer; an enormous amount of bacterial action is carried on continuously here. Organic matter and infections of all kinds find their final resting place in the soil and are there disposed of. Most of the bacteria found in the soil are saprophytic ones growing so profusely that they crowd out the pathogenic kind. When a dead animal body filled with pathogenic bacteria is buried in the soil the saprophytes immediately set about destroying the pathogens. Not only that, but the tissues of the animals as well are gradually disintegrated and consumed—leaving as a rule only the skeleton. Darwin has shown that earthworms, for example, by their plowing action constantly turn over the soil. They also fertilize the soil.

The composition of soil is important from a hygienic point of view. The difference between a sandy and gravelly soil depends mainly upon the size of the particles, the main ingredient in both being silicon dioxide. In clay soil the particles are of the smallest possible size. It is consequently very cohesive, possesses a high degree of plasticity, and plays a very important part in determining the fertility of soil. Clay soil holds water but sandy soil permits of rather free filtration. Loam consists of a mixture of sand, clay, and humus. Humus is decaying animal and vegetable matter and is responsible for the richness of the soil. "Rich soil" is very complex in nature but all rich soils contain a relatively large amount of nitrogen which exists either as protein and its intermediate products, ammonia and its salts, or nitrous and nitric acids, the nitrites and the nitrates.

Hygienic Significance: Hygienists have long recognized the fact that low swampy ground is a breeding place for mosquitoes. Sanatoria are usually built on highlands because of the drier and more stimulating atmosphere. However, it probably is not true that dwellings built on filled ground such as dumps and the like are a menace to health.

Comparatively few pathogenic bacteria remain viable in the soil. Notable examples of these few are the spores of tetanus, malignant edema, anthrax, and the gas bacillus. During the two World Wars these organisms infected wounds on the battle field and were a constant menace to lives of wounded soldiers. In World War II active immunization with tetanus toxoid prevented tetanus.

On the other hand, the eggs and larvae of hookworms and round worms are very numerous in the soil and often find their way into the human body.

The chemical composition of the soil has very little if any hygienic significance. The physical properties on the other hand are very important from the standpoint of health. These physical properties are: (1) porosity or (2) permeability, or the ability to allow the passage of water. This does not depend upon the pore volume, but upon the size of the individual pores. (3) Soil temperature which comes mainly from the sun but partly, though slightly, from chemical changes, and the heat of the earth's interior. (4) Absorption or the ability to extract odors and gases from the air or decomposing soil very much as charcoal does. Illuminating gas from leaky mains is probably deodorized to an enormous extent, which indeed may increase the danger because its presence in houses may be undetected. (5) Soil air and the constant interchange between soil air and the atmosphere. Pollution of the soil air with artificial illuminating gas rich in carbon monoxide is an ever present danger, not so great in rural districts as in urban communities where it may be aspirated into cellars by the suction action of the drafts of furnaces if the cellar is permeable. (6) Soil water and the passage of water through the soil. A desert soil, which is absolutely dry, is lifeless. A soil with an excess of moisture is usually a swamp with the water level at or near the surface.

In addition to the water found in the interstices of the soil a very large quantity of water exists under the soil. This water is of great hygienic importance for a large proportion of mankind derives his

drinking water from natural openings such as springs or from dug or driven wells.

From a hygienic standpoint the pollution of the soil is its most important problem. The soil is capable of disposing of great quantities of organic matter even though it can become overburdened and may endanger health through contamination of the drinking water and in other ways. The purifying action of the soil is largely dependent upon bacteria. Bactericides are also present. It takes time for the soil to act as a scavenger and heavy and constant pollution with *Eberthella typhosa,* hookworm ova, and other animate agents greatly endangers health. A special hazard exists in limestone regions where permeability is so great, due to the fissures in the rocks, that cesspools may be drained into the wells. It must not be forgotten also that vegetables fertilized with human excreta may readily carry infection to man. Of the diseases carried by the soil, two in particular, tetanus and hookworm, are very serious and fairly widespread.

Tetanus: Compared with such diseases as tuberculosis and pneumonia, tetanus is rare. It was known to the ancients and because of its dramatic symptoms impressed them greatly. Nicolaier first demonstrated its cause to be the *Clostridium tetani* in 1885 and the Japanese scientist, Kitasato, grew the microorganism in his laboratory in 1889. The tetanus organism produces an exotoxin for which fortunately there is an antitoxin. It is, therefore, an intoxication and not an infection. For all practical purposes it may be regarded as a wound contamination solely, for the bacillus lives in the intestines of herbivorous animals and man without producing symptoms.

The tetanus bacillus is an anaërobic organism and wounds which are chronically infected favor anaërobic conditions. They permit the tetanus spores to germinate and encourage the growth of the bacillus and the development of toxin. Wounds of the following kind are particularly susceptible:

1. Lacerated wounds where the flesh is torn.
2. Contused wounds where the flesh is crushed.
3. Puncture wounds especially when made with a rough or rusty instrument.
4. Wounds obtained in stables.
5. Wounds contaminated with the soil.
6. Wounds obtained from firearms or Fourth of July fireworks, especially blank cartridges containing horse hair.

7. Sometimes vaccination wounds when the wound becomes contaminated with dirt.

The normal habitat of the tetanus bacillus is in the intestinal tract of herbivorous animals. Animals on the farm harbor more bacilli than those living in the city. Spores of the organisms are taken with the food, are not affected by the gastric juice and finally find ideal anaërobic conditions for growth in the small intestine. When they are discharged with the feces they die, but their spores remain indefinitely in the soil in regions inhabited by man and domestic animals, such as cows and horses.

The soil in certain localities is especially rich in tetanus spores. The recent battlefields of Continental Europe, certain regions in the eastern United States, notably on parts of Long Island and in New Jersey have been noted for the large number of cases of tetanus. Formerly epidemics in lying-in hospitals were very common. Wherever the soil has been heavily fertilized with horse or cow manure the incidence of tetanus is likely to increase in that neighborhood. Tetanus is more prevalent in the tropics than in colder climates.

Because horse serum is the common vehicle for antitoxin and because tetanus spores are so prevalent in horse stables, sera obtained from horses has been known to carry the disease in the past. The same is true of vaccine virus obtained from the cow. In recent years much good has been accomplished by the careful standardization and bacterial examination of biological preparations used in medicine. Credit is undoubtedly due the United States Public Health Service in making tetanus contracted from vaccines a very rare disease.

The incubation period in man is usually from 6 to 14 days or longer depending upon the amount of contamination of the wound, the amount of toxin produced and the consequent severity of the disease. Most cases with a short incubation period prove fatal. The toxin travels up the axis cylinders of the nerves to the spinal cord and the brain. Wounds on the foot contaminated with the tetanus bacillus therefore will have a longer incubation period than wounds on the face. The outcome of tetanus is uncertain; the case fatality rate is usually about 50 per cent.

The spores of tetanus are very resistant to influences which kill ordinary bacteria. The bacillus on the other hand is readily killed even by exposure to the air. The spores will not germinate into bacteria

unless ideal anaërobic conditions are present such as occur in deep wounds. The most reliable methods of killing the spores are with steam under pressure sufficient to raise the temperature to 120° C. for 20 minutes or dry heat of 160° C. for 60 minutes.

The prevention of tetanus consists in efforts directed against the environment and personal prophylaxis:

1. Play fields should never be fertilized with manure. Injuries are common in such places.
2. Safe and sane Fourth of July practices will eliminate a certain number of perennial cases.
3. Debridement should be performed on all wounds contaminated with dirt in order that oxygen may gain access to the tissues.
4. Wherever tetanus is likely either from the location where the wound was contracted or from the nature of the wound, tetanus antitoxin should be given. This antitoxin must be given before the advent of any symptoms.
5. Formalin is recommended as a local disinfectant in the wound.
6. Immunization with tetanus toxoid is recommended for those whose occupations expose them to tetanus.

Hookworm. The disease is world wide and very common in every tropical country. It is common in the southern states where the frost does not enter the ground. In Europe it is chiefly an occupational disease occurring in miners, brickmakers, and tunnel workers.

The adult hookworm, about $\frac{1}{4}$-$\frac{1}{2}$ inch in length, lives in the intestinal tract, usually in the small intestine. It attaches itself to the intestinal wall, sucks blood, eats the epithelium, and produces a toxic substance which injures the host. The female lays a large number of eggs in a never ending stream which pass from the host in the excreta. The embryo does not mature within the egg except in the presence of oxygen. Therefore, the eggs must be discharged into the outer world before full development takes place. The embryos become mature within the egg in 6 to 8 hours in the presence of moisture, warmth, and oxygen. Under favorable conditions the embryo escapes from the egg and becomes a larva in about 24 hours. This free living larva exists and moves in moist soil and feeds upon the organic matter found there. In several days it sheds its skin and passes to the first molt. In about a week it again sheds its skin. In this second molt the parasite is capable of infecting man by piercing the human skin. In the soil it may exist in this stage for five months or longer and be infective for those who go about barefooted.

The hookworm larva passes through five stages or molts. Two of them occur during its free living stage and three of them after it gets into the host. The larva pierces the skin and passes by a circuitous route to the intestinal tract. The parasite may enter the skin at any place but usually it goes through the soft and thin skin between the toes. In its passage through the skin, the larva produces an inflammatory reaction ("ground itch" caused by a parasite and bacteria carried along with it). After the parasite pierces the skin it enters the subcutaneous tissue and finds its way to the lymphatics. It passes through the latter to the thoracic duct, thence to the vena cava and the right heart. From the right heart it goes to the lungs and being too large to pass the capillaries of the lungs, it pierces the capillary walls and appears in the air cells. Then it passes up the bronchi and trachea to the throat, and is then swallowed and finally lodges in the small intestine. During this passage through the body, the larva passes through the last three molts.

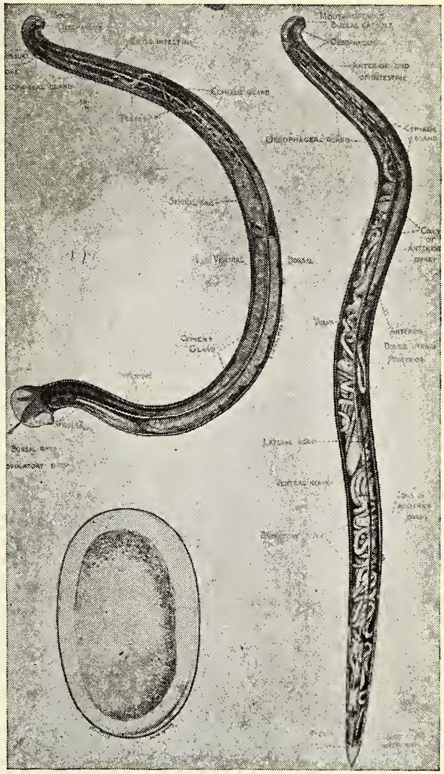
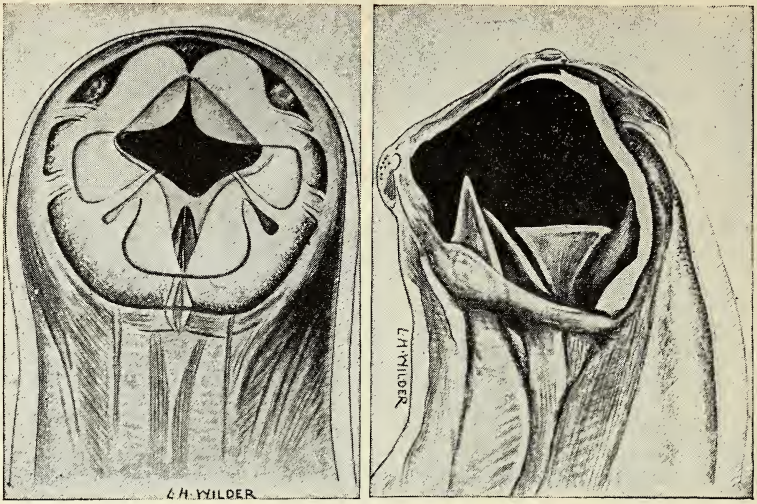


Fig. 51. Male and female hookworms, enlarged. Egg of hookworm, greatly enlarged.
Courtesy Rockefeller Foundation

The symptoms are usually lassitude, malnutrition and anemia. Sometimes remarkable perversions of appetite occur, the patient often becoming a dirt eater.

There is no acquired immunity, but a very definite racial immunity. Negroes and Filipinos have comparatively slight symptoms. The Negro, however, in this country is the great reservoir for hookworm



MOUTH HEAD

FIG. 52. Head of hookworm, greatly enlarged.

FIG. 53. Larva of hookworm in subcutaneous tissue, enlarged.
Both Courtesy Rockefeller Foundation

disease in that he is frequently infected but slightly affected. It is conjectured that infection was brought to America through the Negro slave trade.

FIG. 54. Pedro C., aged 23. A worker on a sugar plantation infested with hookworm. Note the emaciation, the edema of the abdomen and the legs.

FIG. 55. Pedro C., five years after treatment. Note that he looks younger, and well-nourished.

Both Courtesy Rockefeller Foundation

The prophylaxis of hookworm consists in preventing the pollution of the soil and in treating existing cases so as to diminish the amount of infection. The prevention of soil pollution is the key to the situation. Most of the rural homes in the South are without means for the proper disposal of waste material. Add to this the custom of going barefooted and we have all the factors necessary for the dissemination of this disease. Education is one of the most important factors, for the control of the disease depends upon improvements in the sanitary habits of the people. The best place to begin the process is with the school children and even then it will take a generation or more to show any results. The prevention of hookworm is a question of decency and

cleanliness. Personal preventive measure consists in wearing shoes, and otherwise avoiding contact with the infected soil. Other measures which are obvious are boiling the drinking water, cooking all food stuff, and personal cleanliness.

Treatment of the disease is usually very satisfactory when intelligently carried out. It has consisted in the past of the use of thymol, oil of chenopodium, or tetrachlorethylene.

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8

THE RELATION OF AIR TO HEALTH

Older Concepts concerning the Atmosphere: Hippocrates in the fifth century B.C. classed air as one of the elementary substances along with earth, fire, and water and thought these four substances influenced the four humors of the body thus producing disease. But Hippocrates and his greatest follower, the English physician Thomas Sydenham (1624-89), considered air to have a greater significance than anything else in the causation of disease. The former predicted a pestilence in Attica which he ascribed to the air and its being carried by the prevailing winds from the direction of its original outbreak in a nearby place. He also wrote a treatise on "Airs, Waters and Places." Sydenham was the first great epidemiologist.[1] "He regarded 'acute diseases' as proceeding 'from a secret and inexplicable alteration of the air, infecting men's bodies,' and even suspected smallpox of being air borne when he wrote: 'the constitution of the air being not so inclinable to produce the Bloody-Flux gave occasion to the Small-Pox.' "[2]

Ambroise Paré thought that plague was a wet and putrid fever proceeding from an infected and corrupted air and from alteration of the corporeal humors.

Bascome on *Epedemic Pestilences,* 1851, as quoted by Newsholme says:

> All epidemic diseases are to be accounted for on the principle of natural causes, *viz.,* that atmospheric disturbance, consisting of variations of temperature, hygrometric influence, atmospheric pressure, electric tension, etc., are the exciting causes; while, on the other hand, want of light, impure air, especially from defective ventilation, in which are included malaria and all other noxious vapours, from whatever source arising; scanty diet, and habits induced by the irregular artificial life of many, are the predisposing causes,

[1] Newsholme, Sir Arthur. *Evolution of Preventive Medicine,* p. 32. Baltimore, The Williams and Wilkins Co., 1927.

[2] *Ibid.,* pp. 61–62.

which by enervating and otherwise spoiling the system, render it more susceptible of external atmospheric impressions in the production of epidemic pestilence or disease.

Most writers up to the time of Pasteur thought contagious disease to be carried by the air and modern investigation seems to bear them out, in certain respects at least. In the early days of antiseptic surgery, Lister and his helpers operated in a spray of antiseptic solution and dressed wounds with large quantities of cotton to keep out the air or at least the microorganisms of the air.

Until the end of the eighteenth century the function of air was supposed to be to cool the body from the heat generated in the heart and to expel its smoky vapors. Sir Thomas Clifford Allbutt remarks, "How man became such a fiery dragon was the puzzle." The steps in discovery of the real function of the air were these: in 1660, Robert Boyle demonstrated that air was necessary to animal life and to combustion both; in 1667, Robert Hooke demonstrated artificial respiration by means of a bellows inserted in a dog's trachea; in 1669, Richard Lower of Cornwall injected purplish venous blood into a lung containing air and saw it change to bright red blood; John Mayow assumed that something was extracted from the air. This something remained unknown until Priestley and Scheele discovered oxygen in 1771 and Antoine-Laurent Lavoisier showed that an interchange of gases took place in the lungs and that oxygen was absorbed and carbon dioxide emitted (1775).

Modern Concepts Concerning the Air: People do not now fear the air as much as they formerly did when they closed all the windows at night, covered the top of their large four-poster beds with a canopy and after they had gone to bed tightly drew together the curtains hanging down on all sides. As a rule, disease is not carried far from the patient except through the agency of an insect vector such as a mosquito or fly.

One of the most important factors in the contamination of air is the overcrowding of rooms and buildings with people. In such cases infection, especially the respiratory variety, may be later transferred to others using these rooms. Overcrowding of barracks in wartime caused a marked increase in the incidence of respiratory infection among the military personnel. When tests were made for bacterial content of the air such concentration was found to vary directly with the number

of men using the quarters and with their activity.[3] Hemolytic streptococci were found in abundance in the air, in dust, bedclothes, etc.[4] The results of observations would seem to indicate that it is altogether likely that much infection can take place from contaminated air.

The greatest menace from the air is due to the presence of circulating dust which may contain pathogenic bacteria able to produce disease but dust is a hazard in itself. C. A. Mills found a definite relationship between sootfall in Pittsburgh and Cincinnati and high pneumonia death rates in these two cities.[5] Smoke laden atmosphere is a menace to health in several ways. In addition to the irritating action of the soot, beneficial ultra-violet light is filtered out by smoke and other dust.[6]

A large number of dust diseases exist which are usually classed as industrial conditions. Dust is finely divided solid particles floating in the air which have a tendency to settle out. When dust produces a respiratory disease in man the disease is called a pneumoconiosis. The long-continued inhalation of dusts which cannot be eliminated by the lungs causes a fibrosis of lung tissue, a condition characterized by thickening of the membranes and other structures in the lungs. This replacement of lung tissue with scar tissue interferes with respiration and increases the susceptibility of the individual to pulmonary diseases such as tuberculosis and pneumonia. The result derived from inhaling silicon dust (finely divided sand) leads, in time, to silicosis, the most disabling of all the pneumoconioses. The inhalation of soot or coal dust produces anthracosis, which is not nearly so disabling as silicosis, but which does produce a certain amount of impairment of lung function. Ventilation systems which include air filtration in buildings do much to reduce the dustiness of air and even reduce the bacterial content.[7]

[3] Lemon, H. M., Wise, Henry, and Hamburger, Morton, Jr. "Bacterial Content of Air in Army Barracks." *War Medicine,* v. 6, pp. 92–101, 1944.

[4] Robertson, O. H., Hamburger, Morton, Jr., Loosli, C. G., Puck, T. T., Lemon, H. M., and Wise, Henry. "A Study of the Nature and Control of Air-borne Infection in Army Camps." *Journal of the American Medical Association,* v. 126, pp. 993–1000, 1944.

[5] Mills, C. A. "The Relationship of Smoke to Pneumonia and Other Infections of the Respiratory Tract." *Cincinnati Journal of Medicine,* v. 27, pp. 624–33, 1946.

[6] U. S. Public Health Service. "Report on Sunshine, Smoke and Dust." *Journal of the American Medical Association,* v. 133, p. 334, 1947.

[7] Lemon, *et al. op. cit.*

In addition to the ordinary dust diseases there is a special hazard in air containing dust, fog, and noxious chemical vapors. A number of deaths occurred in Donora, Pennsylvania from chemically contaminated "smog" (smoke and fog) in 1948.

The disinfection of air in closed spaces with germicidal vapors or ultra-violet light has created much interest and comment. At the present time the problem is largely technical but a soltuion may be at hand.[8] The glycol vapors have been used, especially triethylene glycol, which seems to be more effective than the others.[9]

Experiments in ultra-violet irradiation of barracks and schoolrooms would seem to indicate that such practice results in a diminution of respiratory infection among those who inhabit these rooms.[10] Such irradiation is fraught with technical difficulties and any apparatus installed by the inexperienced engineer is apt to lead to untoward results such as skin burns, eye irritation, and other complications among those exposed to irradiations for periods of time.[11]

Perhaps the most important relationship of the air to health, certainly to comfort, is concerned with its physical properties; the amount of heat and moisture it contains and its movement. Air that is too warm, that contains much moisture, and lacks movement is enervating. Improvement in any one or all of these factors promotes bodily comfort and probably improves health. The individual can tolerate higher temperatures if the air is dry and in motion. Desert air of the western United States often has such properties. Increasing air movement with electric fans in a warm and humid room will often relieve distress. Air that is relatively cold, damp, and drafty rapidly causes chilling of the body with consequent loss of body heat and increased suscepti-

[8] Robertson, O. H. "Disinfection of Air by Germicidal Vapors and Mists." *American Journal of Public Health,* v. 35, p. 842, 1945.

[9] Bigg, E. B., Jennings, B. H., and Olson, F. C. W. "Epidemiologic Observations on the Use of Glycol Vapors for Air Sterilization." *American Journal of Public Health,* v. 35, pp. 788–98, 1945.

[10] Wheeler, S. M., Ingraham, H. S., Hollaender, Alex., Lill, N. D., Gershon-Cohen, J., and Brown, E. W. "Ultraviolet Light Control of Air-borne Infections in a Naval Training Center." *American Journal of Public Health,* v. 35, pp. 457–68, 1945.

Wells, Mildred W. "Ventilation in the Spread of Chickenpox and Measles within School Rooms." *Journal of the American Medical Association,* v. 129, pp. 197–200, 1945.

[11] Coblentz, W. W. "Ultraviolet Lamps for Disinfecting Purposes." *Journal of American Medical Association,* v. 127, p. 1166, 1944.

bility to respiratory infections such as head colds, bronchitis, and pneumonia. Moderate heat, relative humidity, and gentle air movement is considered optimum for man.

Air as a Carrier of Allergic Substances: Many of the substances which cause allergic reactions in sensitive people are air borne. Such substances are usually the pollens of plants, epidermal scales from domestic animals, and organic dusts of all kinds. The reaction of the individual to such substances usually expresses itself as hay fever or asthma or both.

The air-borne pollens are the important causative agents in hay fever and almost any pollen may cause this condition if present in high enough concentrations. The spring type of hay fever in Eastern United States begins around the first of April and extends through May; it is due to the pollen of common trees such as the poplar, oak, elm, hickory, ash, etc. The summer type occurs in June and the first half of July; it is caused by the pollens of grasses, plantain, and sorrel. The fall type begins around the middle of August and continues, as a rule, until the first frost; it is due mostly to the pollens of rag weeds.

The nonseasonal types of hay fever are usually caused in the allergic individual by the inhalation of dust containing horse, cat or dog dandruff; powders derived from orris, rice, corn, wheat, cotton seed, kapok, hay, etc.; house dust (a complex and variable substance); spores of various fungi. Hay fever may also be caused by the ingestion of certain foods and drugs. Asthma, which has many causes, may also be induced by air-borne substances.

Health workers are advocating the early cutting of rag weeds and spraying with effective weed killers. The latter practice gives promise of success if carried out on a very broad scale. Inasmuch as weeds are so widespread and their pollens are carried such long distances by the winds the actual solution of the problem may be so costly as to be impractical.

Poison Ivy: It is probable that most cases of poison ivy dermatitis come from but one genus of the plant *Rhus*. Rhus dermatitis is contracted by contact with a chemical called urushiol excreted by these plants. It is a nonvolatile oily resin which is not air borne unless the plant is burned in a fire; under such circumstances enough of the substance urushiol may cause a dermatitis when an individual is in contact with the smoke. Rhus poisoning is an allergy but attempts to desensi-

tize the susceptible individual by injection have been disappointing. The chewing of Rhus leaves is considered dangerous. The plant may be killed and thus eliminated by spraying with a solution of 2-4-D (2-4-dichlorophenoxyacetic acid) which will kill all broad-leaved plants when applied to them in sufficient concentration. Avoidance of contact with the plant is the only effective personal preventive.

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9

WATER AND WATER-BORNE DISEASE

Historical Consideration: The need for a pure water supply had been recognized since ancient times. In Rome, before the Christian era, numerous aqueducts carried pure water from mountain streams down into the city where it was distributed for drinking or bathing. Mankind soon discovered that water which came from inhabited regions often carried disease and that the boiling of any water would make it safe for human consumption.

In 1854, attention was first called to water as a carrier of disease when a study of the epidemic of the Broad Street Well, London, was made by one Dr. Snow. An account of this epidemic and others is given in W. T. Sedgwick's *Principles of Sanitary Science and Public Health.* When investigators followed the fate of the people who drank water from this well it was noted that a large number of them contracted Asiatic cholera. This disease had been brought to London by travelers from the Orient. Upon examination it was found that drains in the neighborhood of the Broad Street Well were defective and were permitting the free access of sewage from neighboring houses to the well. Although the microbe of cholera had not yet been discovered the investigation demonstrated conclusively that cholera was transmitted by means of water contaminated with human discharges.

The typhoid epidemic of Lausen, Switzerland (1872), demonstrated the fact that typhoid bacilli could be carried some distance underground in the water without losing their infectiveness.

In the spring of 1885, an epidemic of typhoid fever occurred in Plymouth, a mining town in Pennsylvania, which was definitely traced to a case of typhoid fever contracted in Philadelphia during the Christmas holidays of the year before. The untreated feces of the patient were deposited on the bank of a small frozen creek and found their way into the impounding reservoirs of the town following the

spring thaw. The epidemic showed that the excreta from a single case of typhoid fever could start an epidemic in a town, that freezing does not kill *Eberthella typhosa,* and that typhoid fever is usually a water-borne disease. Studies of this epidemic started a movement for pure water supply which reached all parts of this country.

The cholera epidemic in Hamburg, Germany, in 1892, demonstrated the effectiveness of sand filtration in purifying a water supply. Hamburg and Altona were separate cities politically but geographically they merged. When Asiatic cholera broke out with epidemic violence the cases seemed to be separated by a definite line, the street which served as a common boundary of the two cities. On the Hamburg side of this boundary there were a large number of cases of Asiatic cholera, on the Altona side there were very few. Both towns were situated on the Elbe River and used its water for drinking purposes, but Altona (which was down stream from Hamburg) first filtered its water while Hamburg did not. Robert Koch, the famous bacteriologist, investigated this epidemic and reported it in detail. The source of the epidemic seemed to be a group of Russian immigrants awaiting embarkation for the United States.

Numerous other epidemics are on record which seem to indicate these facts with reference to typhoid fever, cholera, and dysentery:

1. The patient with these diseases in either the active or convalescent stage is the source and fountain-head of new cases.
2. Microbes are eliminated in the discharges from a patient and find their way into the water supply or food of the susceptible individual.
3. All water around human habitations is likely to carry these diseases unless properly protected or treated.

Typhoid Fever: This disease is caused by the *Eberthella typhosa* which attacks almost all of the tissues of the body but which causes mostly intestinal symptoms. It is usually transmitted by water but it may also be carried by food (including milk), flies, and fingers. It prevails in warm weather and in cities is often a vacation disease, *i.e.,* the victim usually contracts it while on vacation in the country. Its prevalence has been materially lessened in recent years due to the extension of sanitary sewage disposal and water purification. Fortunately there is a safe and trustworthy vaccine which is in general use and which has done much in preventing the disease. (See p. 71). Personal phrophylaxis is within the reach of everyone, and its effective-

ness has been demonstrated among the officers and men of the United States Army. During the Civil and Spanish-American Wars typhoid

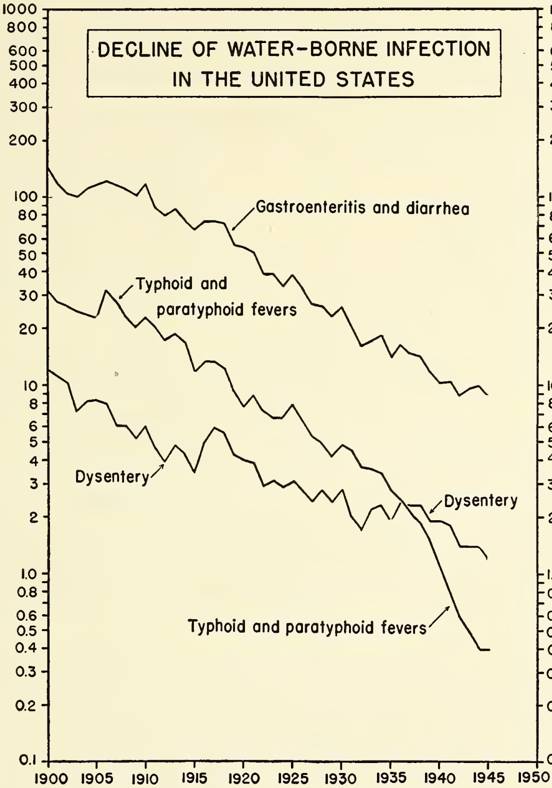

FIG. 56. Death rates of certain water-borne diseases. These rates are from official data for the registration area of the United States and are the number of deaths per 100,000 population for each condition shown. The curves in this chart are plotted on the semi-logarithmic scale for better comparison of rates. Gastroenteritis and diarrhea of infants and small children is frequently milk-borne (see Fig. 77). Typhoid and paratyphoid fevers are often food-borne (see Chap. 8).

fever was more deadly than bullets. During World Wars I and II typhoid fever was rare.

Paratyphoid Fever: This is similar to typhoid fever and caused by the *Salmonella* organisms. (See Chapter 11.)

Hookworm: This is sometimes transmitted by water. Hookworm has been described on pp. 120-124.

Dysentery: This is a widespread disease which prevails mostly in tropical climates. It is essentially a warm weather disease of temperate climates and attacks infants and children more frequently than adults. Many of the cases of summer diarrhea among infants are dysentery produced by a bacillus. A pathogenic ameba produces amebic dysentery which is very prevalent in the tropics, and is sometimes brought to temperate climates by travelers. The bacillary type of dysentery is usually considered water borne, although fingers, food, and flies may also carry it. The principal symptoms are gastrointestinal, although it is a general disease.

Asiatic Cholera: This is an Asiatic disease whose focus is in the delta of the Ganges. On numerous occasions cholera has spread over the whole of the civilized world. It followed trade and travel, and eternal vigilance was necessary to keep it out of all countries. Quarantine has been very effective in this respect in the United States. It is prevalent in the Orient where almost no precautions are taken against it by the fatalistic inhabitants. Cholera is spread by cases or carriers whose discharges reach a drinking water supply. It is also transmitted by vegetables fertilized by human excreta.

Purification of Water: Methods for the purification of water exist in nature. Leeuwenhoek in the seventeenth century scrutinized freshly fallen rain water under his microscope, and noticed that it was free from bacteria. The creation of rain is simply evaporation and condensation of water, which effectively purifies it. This process is analogous to distillation. The storage of water in lakes and ponds tends to rid that water of pathogenic bacteria, for the latter will not multiply outside of an animal body, as a rule (see p. 46). Pathogenic bacteria eventually disappear from sewage which has been stored in a septic tank; if sewage is stored long enough in nature these bacteria do not find their way into water (see p. 220). Aëration of water takes place when it flows over stones and waterfalls, and is accompanied by oxidation from the oxygen of the air. Oxidation destroys bacteria. Finally water, in percolating through gravel and sandy soil, is freed of bacteria.

In the artificial purification of water man simply imitates nature's processes. In some cases where drinking water is obtained from a large body of fresh water, such as one of the Great Lakes, an intake is placed far out in the lake and far removed from any source of contamination such as a sewer. Water is drawn from the lake into a pumping station and distributed. Usually such a supply is chlorinated to safeguard it. Chlorination, it will be remembered, is actually oxidation, for liquid chlorine mixed with water liberates nascent oxygen from the latter, which in turn oxidizes and thus destroys pathogenic bacteria. The amount of chlorine needed varies with the amount of contamination.

Where water is obtained from a river, or some other source apt to be contaminated with human discharges an elaborate system of water purification is necessary in order to prevent the spread of disease. Of course, the most grossly polluted water may be consumed after it has been boiled, but people, as a rule, do not like the taste of boiled water, and are apt to consume it raw. In the United States Army water is treated by adding chlorinated lime to raw water, but this also gives an objectionable taste. The Army still uses this method but only as a last resort. Small amounts of tincture of iodine may be added to suspected water, but this also has its objections. Experience has shown that a specialized type of treatment is necessary for most river water. The water works of Cincinnati, Ohio, will be decribed as a plant which has been highly successful in delivering to the citizens water of the highest possible purity.

The Cincinnati Water Works: The history and development of the Cincinnati water supply has been interesting and instructive as typical of the problem of obtaining water for a large city in a populous river valley. In the early days springs were abundant in the Ohio Valley, and the water even bubbled up from between the gravel and sand of the beaches along the river bank in the town. This was especially true at the bases of the hills which bound the old city. When these failed in supplying a growing population, wells were sunk, and provided with hand pumps. In addition water was carried from the Ohio River in barrels and sold to the people. In 1817, a water company was formed but did not function until a change in management took place and the company finally delivered raw river water to the citizens in 1821. The machinery of the pumping station was of wood, and two horses or oxen working on two circular treadmills supplied the power.

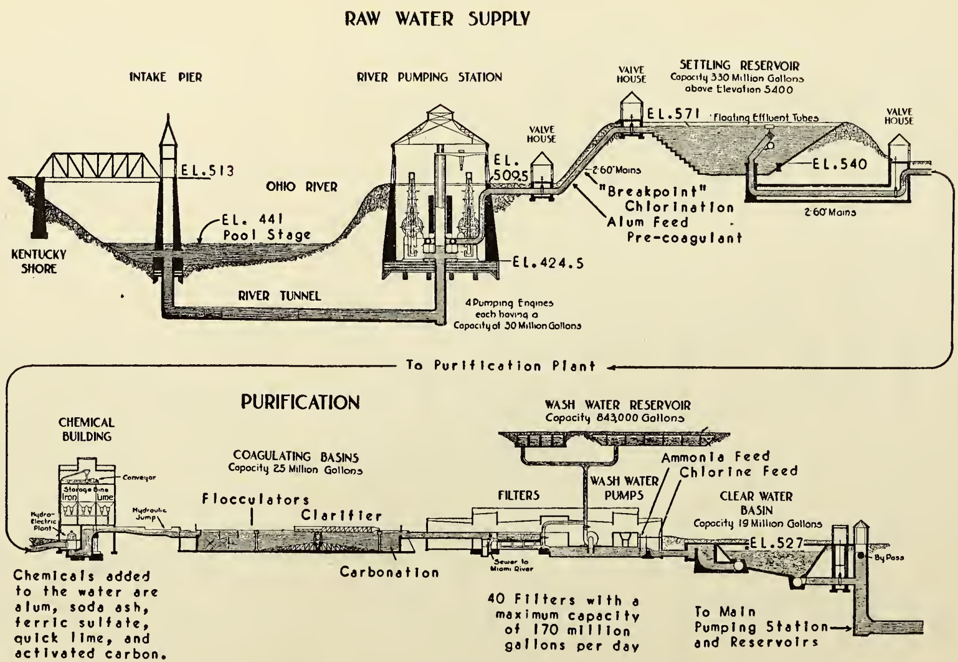

FIG. 57. Diagram of the Cincinnati Water Works, California, Ohio

In 1824, a steam pump supplanted the animals as a source of power and the company was able to deliver 1,200,000 gallons of water a day. This company and its successors ran into a series of difficulties until the city finally purchased the water company in 1839 at a cost of $300-000. Through the years the city constructed many reservoirs, improved

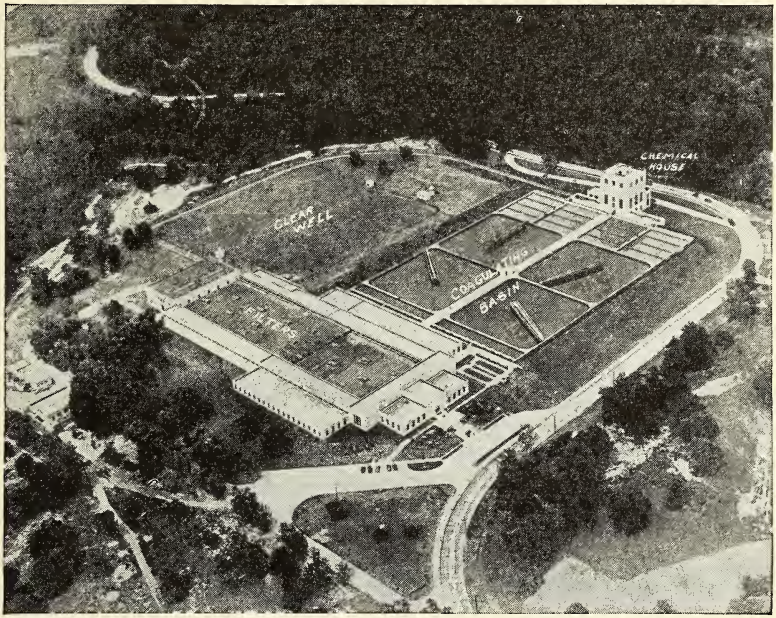

FIG. 58. The water purification plant at California, Ohio shown diagramatically in the lower half of Fig. 57.

their pumps, built new pumping stations, built standpipes on the hilltops, and tried to supply the citizens with plenty of water. The Ohio River became grossly polluted, and the city suffered numerous epidemics of intestinal disease which could be definitely traced to its water supply. In 1896, the state legislature passed the Water Works Act which was contested in the courts by private citizens and corporations which delayed considerably the construction of the present water works. These works were finally completed however and put into operation in 1907. Major improvements were started in 1936 and completed in 1938. They were interrupted by the great flood of 1937,

the crest of which reached 512 feet above sea level, and stopped the water supply of the city for 10 days. The river reached a depth of 80 feet during this flood.

A diagram of the purification system of the Cincinnati Water Works is reproduced in Fig. 57 and an aerial photograph of the main purification plant is shown in Fig. 58. The intake pier is located near the Kentucky shore. Within this pier there is a traveling water screen which is designed to remove debris; it screens about 150 million gallons of water per day. It is in the form of a continuous belt constructed of 112 heavy bronze wire screen panels connected together by sprocket chains.

Water passes from the pier to the intake tunnel and thence to the river pumping station. Being below water level, especially in flood times, particular construction is necessary to keep this building in place and on its floor 9900 tons of weight are required for this purpose.

The purification process has four distinct phases as follows:

1. Preliminary sedimentation. Water pumped from the river passes to the primary settling reservoirs on high ground. On the way pre-sedimentation chlorination (called "break point" chlorination) is administered. When the river is unusually muddy, alum solution is applied to the raw water before it enters the settling reservoirs. It requires about 72 hours for the water to pass through these reservoirs. In this phase about 65 to 80 per cent of the impurities are removed by gravity settling.

2. Coagulation and Sedimentation. After the partial purification in the preliminary settling reservoirs, the water flows to the Chemical House by gravity, passing through water turbines by which all of the electric power used at the plant is generated. Certain chemicals indicated in Fig. 57 are added to the water which react with dissolved or colloidal organic matter to form a gelatinous precipitate in which silt particles and bacteria are entrapped. This process results in a coagulation. The water then passes to the flocculator compartments in which it is stirred slowly by large paddles. In this process the precipitated particles, called "floc," are "conditioned" or built up to a proper size and texture which will enable them to settle quickly. After passing through the flacculators, the water flows very slowly through the secondary settling basins on its way to the filters. If properly conditioned most of the floc particles will be settled in these basins and very little suspended matter will be carried to the filters. About 20 to 25 per cent of the original river water impurities are removed by the coagulation and sedimentation process.

3. Filtration. The filters remove all of the suspended matter which has not deposited in the secondary settling basins and almost all the bacteria. In

the filtration process the water passes downward through the sand beds which strain out the suspended particles. When the surface of the filter needs cleaning a flow of pure water is directed upward through the sand. This loosens and removes all of the accumulated flock, flushes it into the collecting troughs, and thence to the sewer. In general, only about 2 per cent or less of the original impurities in the river water will reach the filters, the greater portion having been removed by the preceeding processes.

4. Disinfection. After the water comes from the filters, chlorine, a powerful germicide, is added as the final stage in purification. Ammonia, which acts to lessen the taste-producing properties of chlorine, is added just prior to the addition of the chlorine. After chlorination the purified water enters a covered clear water reservoir from which it flows through the gravity tunnel to the main pumping station and thence to the city distribution system.

The gravity tunnel is 4½ miles in length and 7 feet in diameter. It carries water from the purification plant at California to the main pumping station located in the city proper. From here, where the elevation is 490 feet, the water is raised to a number of tanks and reservoirs the elevations of which vary from 670 to 1,030 feet above sea level. (Most of the city is 500 to 550 feet elevation while the suburbs located on the hills may be as high as 850 feet.)

The water system of Cincinnati is described because it is typical of many found through the Ohio and Mississippi valleys. In this part of the country a special problem in water purification exists. Because these rivers are practically open sewers into which sewage is dumped and drinking water is drawn, near perfect water purification is required for the inhabitants of this reigon to survive.

Most of the rivers and surface wells in the United States are grossly polluted. The deep wells are not entirely safe. As stated above, artesian wells in limestone regions are very apt to become contaminated with intestinal bacteria and produce enteric diseases. The various states maintain water testing laboratories to which samples of well water may be sent for examination. An opinion is given the owner as to the quality of his water and its relative safety for drinking purposes.

The pollution problem in the Ohio river can be appreciated by a study of Table VI, which is a summary of the raw and finished product and its effect on typhoid fever.

When bacteriological examinations were started in 1911 it was found that raw river water averaged 1,330 coliform or intestinal bacteria per

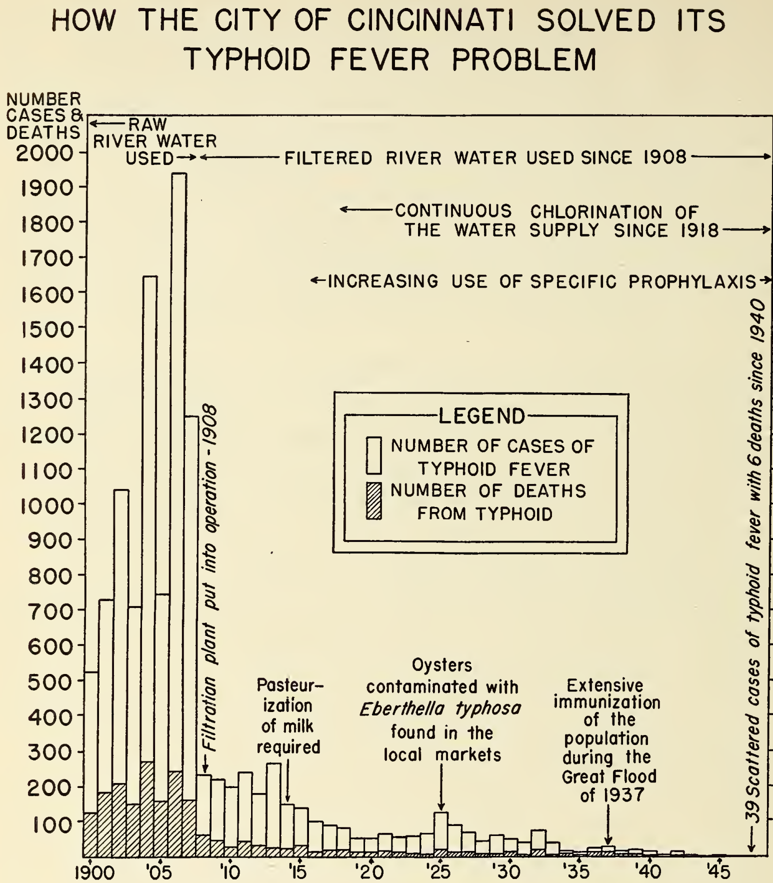

Fig. 59. Marked improvement took place in the morbidity and mortality from typhoid fever following filtration and chlorination of the water supply. Further advance was noted after the elimination of pit privies following instalation of the first intercepter sewer in 1912. This improvement practically eliminated fly borne typhoid fever. Compulsory pasteurization of milk after 1914 resulted in further reduction of the typhoid rate. Extensive specific immunization in both World Wars had a similar effect. Practically no cases of typhoid fever develop in the citizens of Cincinnati who drink only city water and pasteurized milk. Cases of typhoid fever seen in this city at the present time contract the disease outside the city limits.

100 c.c. of water. By 1938 the pollution had increased almost eight-fold. At the present writing (1948) there are about four times as many *Escherichia coli* in a given sample of raw river water as there were in 1911. In spite of this heavy pollution the Cincinnati Water Works has maintained the purity of its processed water and it now shows about one coliform organism per 10 liters of water delivered to the consumer. This is a great improvement in its product since 1912. Ade-

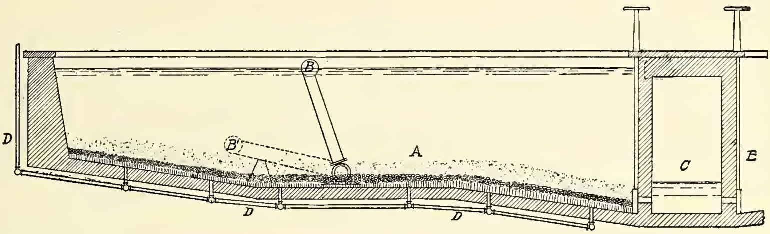

FIG. 60. Diagram of a rapid sand filter (cross-section). *A* is the main filter bed composed of sand and gravel on brick or tile. Raw water enters at *B*, which is a floating intake. When there is no water in the filter the intake sinks to *B'* position. Clear filtered water passes into a flow chamber *C* where it is carried off for further treatment. Another filter chamber is located at *E* which uses the common outlet *C*. When the filter is cleaned, gates between *C* and chambers *A* and *E* are closed; air is passed through *D* to loosen the sand and then filtered water is passed up this same pipe and is drained off through *B* and disposed of as contaminated water.

quate chlorination of the water supply after filtration, which started in 1918, has resulted in a 450-fold reduction of intestinal bacteria since observations were first made. The typhoid fever death rate has been reduced from a high point of 79.8 per 100,000 population in 1904 to zero in 1947.

Communities which enjoy a pure water supply, allow only pasteurized milk to be sold, have a closed sewerage system where flies and other insects cannot breed, require meat and other food inspections, supervise public eating places and food handlers to prevent the spread of communicable diseases will, as a rule, show a low infant mortality rate and generally good health conditions. The foregoing are not all the factors concerned with health but they are among the major ones. The asset of primary importance is that of an abundant, pure, and cheap water supply. It is unquestionably true that, within certain

limits, health can be purchased. A good water system is expensive but is worth what it costs.

Rural Water Supply. The provision of water in rural districts presents a special problem. Water for the home or farm in the country and in many small villages, is obtained from springs, wells, cisterns, streams, and ponds or lakes. The most common of these are springs or wells. The use of surface water such as a stream or pond or lake is

TABLE VI

THE EXTENT OF POLLUTION OF THE OHIO RIVER, THE EFFECTS OF FILTRATION AND CHLORINATION ON THE COLIFORM BACTERIAL CONTENT OF THE WATER AND THE EFFECT OF WATER PURIFICATION ON THE MORBIDITY AND MORTALITY OF TYPHOID FEVER IN CINCINNATI.

Year	*Number of E. coli * per 100 c.c. Raw Water*	*Number of E. coli * per 100 c.c. Filtered Water*	*Number of E. coli * per 100 c.c. Chlorinated Output*	*Number of Cases of Typhoid Fever*	*Deaths from Typhoid Fever*	*Typhoid Death Rate per 100,000 Population*
1911	1,330	7.3	†	238	43	11.5
1912	1,565	10.2	4.5	182	28	7.3
1913	1,265	5.4	2.1	266	24	6.1
1914	1,465	6.0	2.3	148	23	5.9
1915	3,350	17.5	5.8	141	29	7.3
1916	2,155	11.6	7.2	98	13	3.0
1917	3,055	12.2	5.7	89	16	4.0
1918	1,845	6.8	2.0	84	17	4.8
1919	2,190	5.3	0.6	56	11	2.8
1920	1,890	4.8	1.1	56	12	2.9
1921	2,880	3.7	0.4	67	14	3.4
1922	1,655	4.0	0.7	58	13	3.2
1923	1,820	4.3	0.6	62	12	2.9
1924	2,285	4.0	0.22	65	9	2.2

* *Escherichia coli* is a normal inhabitant of the gastrointestinal tract of man and animals, and indicates the amount of pollution, in a general way, in a stream. It is not necessarily a pathogenic organism.

† Chlorination was not started until 1912 when bleaching powder was used for about 5 to 7 months during the year. Adequate chlorination was not practiced continuously until 1918. Since then the amount used has been increased from one pound per million gallons of water in 1918 to six pounds P.M.G. in 1948.

TABLE VI (*Continued*)

Year	*Number of E. coli per 100 c.c. Raw Water*	*Number of E. coli per 100 c.c. Filtered Water*	*Number of E. coli per 100 c.c. Chlorinated Output*	*Number of Cases of Typhoid Fever*	*Deaths from Typhoid Fever*	*Typhoid Death Rate per 100,000 Population*
1925	1,690	2.5	0.27	127 §	17	4.1
1926	3,075	3.7	0.34	89	11	2.7
1927	3,560	3.3	0.09	73	12	2.9
1928	2,960	4.4	0.19	43	7	1.7
1929	2,890	3.1	0.08	61	6	1.4
1930	392 ‡	1.5	0.07	49	10	2.2
1931	1,795	2.4	0.06	38	2	0.4
1932	2,620	4.6	0.17	74	14	3.0
1933	3,030	5.6	0.38	40	4	0.9
1934	2,910	2.9	0.22	16	7	1.5
1935	10,330	7.4	0.33	13	6	1.3
1936	5,410	19.3 ‖	0.72	26	9	1.9
1937	8,440	37.9 ‖	0.57	30	6	1.3
1938	10,580	8.4	0.82	16	4	0.8
1939	4,590	2.1	0.07	18	5	1.1
1940	3,775	2.8	0.30	16	3	0.7
1941	3,720	3.3	0.11	6	1	0.2
1942	5,545	2.4	0.04	16	2	0.4
1943	1,995	2.7	0.05	5	2	0.4
1944	3,080	2.1	0.02	2	0	0.0
1945	4,360	4.0	0.07	4	0	0.0
1946	3,615	5.6	0.01	3	1	0.2
1947	5,165	10.8	0.01	3	0	0.0

‡ Due to drought; river was in permanent pool stage.
§ For this high incidence see explanation given in Fig. 31.
‖ Plant was reconstructed during 1936 to 1938.
SOURCE: *Report of the Cincinnati Water Works 1943-48,* City of Cincinnati, 1949.

always accompanied by a certain amount of danger and is not recommended. This is because of the probability of contamination and the difficulty of rendering such water safe for human consumption.

Water from roofs of buildings may be collected and stored in cisterns, either above or below ground. Rain water is soft and comparatively pure as it comes from the clouds, and the cistern if well constructed and cared for may be satisfactory. Disadvantages, however,

such as the uncertainty of the weather affecting the supply and storage of water, the entrance into the cistern of dust, dirt and bird droppings from the roof or tree roots and contaminating seepage from the surrounding soil, the possibility of loss of water by leakage, the objectionable tàste of the water from concrete walls and the growth and decay of bacteria make other sources of water more desirable.

The water of springs and wells is surface water that has been altered as the result of filtering through the soil. There is less organic matter, fewer bacteria, and a greater amount of mineral matter. The changes affected depend upon the nature of the soil (See Chapter 7) and the distance through which the water has passed. In limestone regions water may travel great distances with little alteration, while in sandy soil there may be considerable filtering action in a short distance. Contaminated surface water may not be purified while passing through the soil. On the other hand, pure water, even in favorable soils, may become impure while in the ground. The direct contamination of the water probably occurs more often at the spring or well and is believed to be more serious. Water from deep or artesian wells, those that extend beyond the first impervious stratum of the earth into a water-bearing stratum below, is usually safe and free from contamination due to the long distance in the soil through which the water has passed.

It is very difficult if not impossible for the individual to provide the means for purifying contaminated water as is done in the case of the community water supply. The problem, therefore, is to find a watershed which will insure pure surface water, to prevent pollution of the water indirectly while it is passing through the soil, and to protect it from contamination at the spring or well. As man is the source of most pathogenic organisms, it is imperative that the area providing the water as well as the ground through which it has passed be protected from human or animal pollution. The well, for example, should be tightly closed with the top extending a foot or more above the level of the ground and so constructed as to insure adequate drainage away from the well. Surface washings from the ground surrounding the well should be drained away.

The location of the well is important. Ground water usually flows in the same direction as surface water and therefore the well should be located above and at least 75 feet (or more if possible) from all

possible sources of pollution such as septic tanks, privies, stables. Spring and shallow wells should be cleaned once a year.

The detailed information necessary for the construction and maintenance of a safe and adequate water supply in the individual home cannot be included in this discussion. Such information may be secured from any local or state health department.

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10

DISEASES SPREAD BY ANIMALS

Diseases spread by animals are contracted by man in several ways: (1) Contact infection or direct transmission from the animal to man. (2) Infection through food, either in consuming the carcass or drinking the milk of the diseased animal. (3) Transmissions from animal to man through the agency of an insect such as a flea or tick. Examples of each type will be evident in the following pages of this chapter.

Bovine Tuberculosis: *Mycobacterium tuberculosis* can and often does attack a number of animals including man (cow, monkey, pig, cat, etc.). Because much of our food (especially milk) comes from bovine animals, bovine tuberculosis used to be one of the important health problems. Milk serves as a conveyer of infection in bovine tuberculosis and is contaminated in several ways: (1) there are tuberculous lesions in the udders of the cows and the organisms are excreted with the milk. (2) tuberculosis in any part of the cow is likely to be excreted in the urine or feces, usually the latter. Sometimes market milk is contaminated with cow manure, which can be demonstrated by passing a quart of milk through clean absorbent cotton in a funnel (filtration). A brown deposit indicates dirt, usually manure. The organism of tuberculosis even when not present in the udder often finds its way to milk through this type of contamination.

Man also contracts bovine tuberculosis by handling the tuberculous meat or eating such infected meat raw or improperly cooked.

Children are the ones commonly affected, largely because they are the principal consumers of milk, and because they are more susceptible than adults. The entrance of the bacteria is usually through the mouth, and most of the lesions are found in the intestines (*tuberculous enteritis*). Tuberculous infection of the lymph glands of the neck (*tuberculous cervical adenitis*) is another common form of bovine tuberculosis. The portal of entry here is usually the mucous membrane of the tonsils or other lymphatic tissue in the mouth or nasopharynx (*e.g.*, adenoids). Tuberculosis of the bones and joints, of the

coverings of the brain (*the meninges*), of the bronchial lymph glands and lungs or generalized tuberculosis is usually due to the human type, rather than the bovine.

Tuberculosis of the skin, although not very common is more frequently seen in those handling infected meat (butchers) than any other single class. Small tubercles form in the skin which may be and often is the only part of the body affected.

FIG. 61. A well-nourished cow with tuberculosis and a positive tuberculin test. From Hadley, *Principles of Veterinary Science.* Copyright W. B. Saunders Co.

The diagnosis of bovine tuberculosis usually rests on two factors: (1) a careful physical examination of cattle and (2) the tuberculin test. The examination usually consists of a careful inspection of an animal for any abnormal signs, palpation of the superficial lymphatic glands and the udder, and certain other procedures. The temperature of the cow can also be taken by rectum and is a valuable aid in the diagnosis. Milk may readily be examined for tubercle bacilli in the laboratory. Sometimes the cow *obviously* has tuberculosis which shows definite signs by physical examination, and which renders unnecessary the tuberculin test. Indeed the tuberculin test is sometimes negative in cattle which are heavily infected with tubercle bacilli. For details of examination of cattle for tuberculosis the interested student is referred to Circular 249, U. S. Department of Agriculture.

If an animal has no fever, and shows no physical signs of tuberculosis the tuberculin test is given. Koch's tuberculin[1] is injected with a sterile hypodermic syringe, after diluting.[2] Nine hours after the injection is made the temperature of the animal is taken and repeated every two or three hours until the sixteenth or eighteenth hour after injection. If no fever results the animal is declared to react negatively to

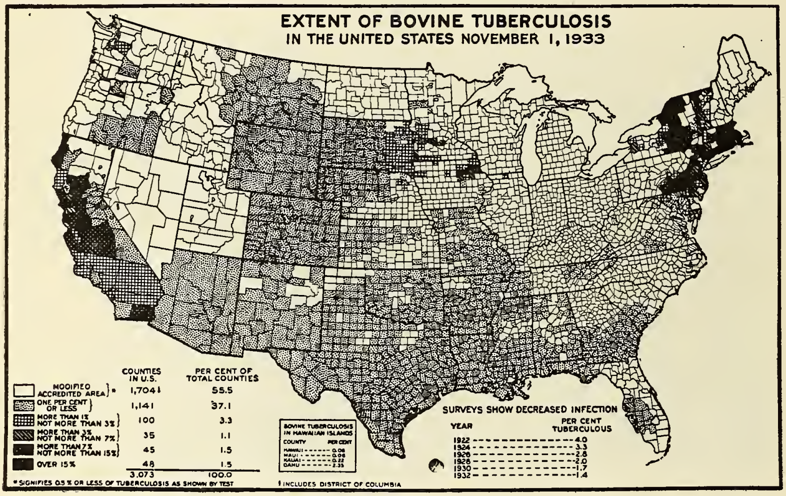

FIG. 62. Extent of Bovine Tuberculosis Among Cattle in the United States. As a result of widespread testing and slaughter of infected cattle the extent of bovine tuberculosis has decreased greatly. In 1948 all counties in continental United States, Puerto Rico, and the Virgin Islands were modified accredited counties; that is 0.5 per cent of the cattle or less showed positive tests for tuberculosis when examined.

Courtesy Bureau of Animal Industry, U. S. Department of Agriculture.

tuberculin and assumed to be free of tuberculosis *at the time of the examination.* If a fever does result the cow is observed for a longer period of time until the temperature falls or until a distinct reaction

[1] Prepared by taking a culture of tubercle bacilli of six weeks' growth on a 5 per cent glycerin broth, killing the bacteria in a sterilizer, filtering to remove the bacilli, and evaporating the filtrate to $\frac{1}{10}$ of its bulk and again filtering. The filtrate is called "Old Tuberculin," "O.T." or "Crude Tuberculin" and is used for diagnostic purposes only.

[2] The tuberculin (O.T.) is diluted by taking 0.4 c.c. of O.T. and adding 5 c.c. of sterile water.

is recognized. These reactions are of three kinds: (1) a general illness with fever, (2) a focal reaction where the animal has tuberculosis, *e.g.*, the udder, the lymph nodes—usually accompanied by a fever, and (3) a local reaction at the chosen site of injection, usually the caudal fold. In carefully standardized testing the local reaction is usually considered sufficient in the tuberculin testing of cattle.

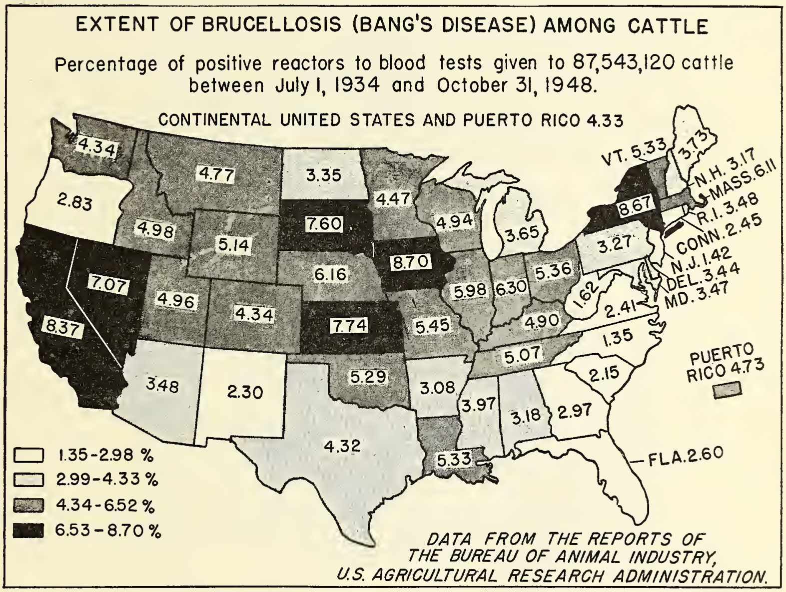

FIG. 63. Brucellosis is also called undulant fever. At the present time pasteurization of milk is the only protection against its spread to humans.

Unfortunately tuberculin-tested cattle may and often do become infected shortly after examination. Therefore it is necessary to pasteurize properly all milk from tuberculin tested cattle if we would avoid bovine tuberculosis. Briefly the prevention and ultimate elimination of the disease rests upon these procedures: (1) Examination of all cattle for tuberculosis and destruction of all those obviously infected: (2) Testing the remainder and destroying those reacting positively to the tuberculin test; (3) Using only milk from tuberculin-tested cattle and only after it has been pasteurized; (4) Inspection of the

carcasses of all cattle slaughtered for food and condemnation of those showing signs of tuberculosis by post-mortem examination; (5) Eating only inspected meat which has been passed as free from disease and which has been thoroughly cooked.

The Bang method of suppressing bovine tuberculosis has been extremely successful in Europe and has the advantage of being less costly than the methods in use in this country. All obvious cases of tuberculosis are slaughtered and the carcasses are inspected. The parts which can be salvaged are sold for food. The cattle which react to tuberculin are isolated from those which do not. Milk from both herds is used but is first carefully pasteurized and then sold or made into butter and the skimmed milk returned to the farmer for feeding purposes. The sediment which remains in a cream separator is burned. Calves of the reacting group are removed from their dams immediately after birth and fed on milk from non-reacting cows or with pasteurized milk. They are tested after three or four months and if they do not react to the tuberculin test they are herded with the healthy animals. The results of this method of *isolation* have proven gratifying and numerous herds in Denmark particularly are free of tuberculosis.

In the United States the Federal Government co-operates with states in the attempted eradication of bovine tuberculosis in testing cattle free, allowing an indemnity in case an animal is condemned. Usually both the Federal Government and the State Government allow the farmer a certain amount of money. Clinically we see much less bovine tuberculosis than we did formerly. The reduction in recent years has been striking.

Brucellosis: This disease is contracted from ingestion of infected milk of cattle and goats and infected meat of hogs and cattle. It is also contracted from eating butter and cheese contaminated with the specific microbes. It was first described by William Burnett in 1814 and called "Malta fever" as it was discovered on that island and other places in the Mediterranean.

The organisms causing the disease are named after Bruce who discovered the organisms in man in 1886.

In man the disease varies somewhat depending on which type of organism causes the infection. *Brucella melitensis* causes Malta fever and the original source of the organism is found in infected goats. *Brucella abortus* causes Bang's disease in cattle and undulant fever in

man. (Bang discovered *Brucella abortus* in 1897.) The symptoms vary and the diagnosis may be difficult. Undulant fever is often suspected from the fever chart in a hospital when the curve on the chart shows undulations or waves in its general contour. Practically all these diseases are contracted by man through drinking raw milk. They can be prevented by the pasteurization of all milk used by man, goat's milk as well as cow's milk.

FIG. 64. Head of a cow with foot and mouth disease.
From Hadley, *Principles of Veterinary Science*. Copyright W. B. Saunders Co.

Plans are now being formulated (1949) for the control of this disease by the Agricultural Research Administration, Bureau of Animal Industry, U. S. Department of Agriculture in co-operation with the United States Livestock Sanitary Association.

Enteritis: Animals suffering from diseases such as fever after giving birth to a calf, "blood poisoning," etc., are apt to furnish meat infected with *Salmonella enteritidis* and similar organisms. So-called "food poisoning" or "meat poisoning" is the commonest disease of cattle transmitted to man. The symptoms in man are usually associated with

an acute gastrointestinal upset, nausea, vomiting, and diarrhea, with or without fever.

The prevention of the disease consists in eating only Federally inspected meat, and that thoroughly cooked. The meat itself gives no clue as to its contamination. Its appearance and odor are natural.

Foot and Mouth Disease: This is rarely seen in humans, although very prevalent in cattle both here and abroad. It is caused by a filtrable virus (see p. 52). The disease causes an inflammation of the mouth, hands, and feet in humans, and of the mouth and hoofs of cloven-footed cattle. It is transmitted to man by drinking infected milk, and from animal to animal in pastures contaminated with the virus, or to the young animal in suckling. It can be controlled by isolation and quarantine, and wholesale destruction of the cattle so affected. It is rarely fatal, but leads to great economic loss among cattle raisers. In the epidemic of 1914 a relatively large number of humans were attacked, more so than before or since then.

Bubonic Plague: The most historic of all the pestilences was the Black Death or as it is now called, the bubonic plague. For centuries it has smoldered in the Orient ready to spring upon the rest of the world the moment public health vigilance is relaxed.

The mortality from plague was so great during the Middle Ages that its ravages are well recorded in history. Epidemics have been too numerous to mention. Tacitus tells us that during a plague epidemic in Rome "Houses were filled with dead bodies and the streets with funerals." In 1345, an epidemic of bubonic plague occurred in Africa and Asia and spread two years later to Constantinople and from there over Europe. It reached England in 1348 and caused about 1,500,000 deaths or between one-third and one-half of the total population of that country. A second visitation of the plague came in 1361-62 and a third in 1369. At this time wages rose to enormous heights, and serfs were encouraged to run away from their lords to work for another lord. Soon it was impossible to keep track of villeins especially after the uprising headed by Wat Tyler in 1381 succeeded in burning the manor rolls. The plague made so many journeys to Europe that it left the people in a hopeless state of mind. Prayers and gifts to the church were unavailing. In 1348, 1,200,000 people made a pilgrimage to Rome from all over the Christian World. Only 10 per cent lived to return to their homes. In the same year the authorities of Venice hit

upon a scheme for preventing plague which is still in general use in a modified form, that of quarantine (see Chapter 13).

In 1664-65, the plague again visited London causing about 70,000 deaths in a total population of about a half-million (see Daniel Defoe's *A Journal of the Plague Year*).

Plague had been absent for about 100 years until it broke out in 1894 in Hongkong, China. Yersin, a young man working in the Pasteur Institute in Paris immediately set sail for Hong Kong and lived in the slums so he could better study the disease. In a short time back came the report from Yersin, "It seems likely that rats constitute its principal vehicle of dissemination, but I have learned, too, that fleas contract the disease and die of it, and therefore become agents of its transmission." This discovery along with the discovery of the germ which causes it (made by Kitasato) has enabled mankind to protect himself against plague. An effective vaccine was developed for protection of individuals.

The disease has figured prominently in literature, the *Decameron* of Boccaccio written in 1348-58, is a collection of stories supposed to have been told by courtiers and ladies who had fled from the plague at Florence in 1348. Benvenuto Cellini describes a plague in the early part of his autobiography. Samuel Pepys' *Diary* also mentions it.

In 1896, plague broke out in Bombay and spread practically over the world. It reached San Francisco in 1900 and caused about 22 deaths there in that year. Between 1898 and 1928 over eleven million people died of plague in India.[3] In the United States 429 deaths occurred between 1900 and 1928, 338 of these were in California, 50 in New Orleans (between 1914 and 1920), 31 in Texas (1920), and 10 in Florida (1920). In recent years there have been no reported deaths from plague in the United States which seems strange as rodents that have died from the disease have been found in most of the states west of the continental divide and even on its eastern slope in Colorado.

In various surveys made by the United States Public Health Service a wide variety of rodents such as ground squirrels, jack rabbits, cottontail rabbits, brush rabbits, wood rats, pack rats, domestic rats, marmots, chipmunks, mice, gophers, badgers, and prairie dogs have been found to be infected with plague.

[3] Rosenau, M. J. *Preventive Medicine and Hygiene,* p. 270.

The disease is prevalent in rodents and even though it is rare in this country great uneasiness exists among public health workers concerning plague. Outbreaks might occur at any time and extend over a wide area.

Plague is caused by the *Pasteurella pestis,* and is primarily a disease of rodents transmissible to man through the agency of the rat flea. It assumes three general types in man: bubonic plague, pneumonic

FIG. 65. Rat guards on hawsers.
From Boyd, *Preventive Medicine.* Copyright W. B. Saunders Co.

plague, and septicaemic plague. Pneumonic plague is a contact disease, occurring chiefly in the Orient, and is very similar to our pneumonia. The bacilli leave the body in the sputum, and the disease is consequently contagious. Bubonic plague is characterized by the presence of enlarged lymph glands or "buboes." It has been called the "Black Death" because of the subcutaneous hemorrhages which turned black. The septicaemic type is characterized by an invasion of the blood stream by *Pasteurella pestis* and is similar to our so-called "blood poisoning."

Inasmuch as plague is endemic in rats, and carried mostly by them, it has been noted that before plague breaks out in any community the rats die of the disease in large numbers. The reason for widespread

epidemics of this disease in the past is two-fold. Rats live close to man as a source of food supply and they are great travelers. They invade ships which carry them around the world. Everyone is familiar with the seasonal migration of rats, to the cities in winter, and to the country in summer. They have been known to travel long distances when their food supply was curtailed. They breed profusely, are easily maintained because they are omnivorous, and have the power of hiding from their enemies in small holes of every description. For most part they remain hidden in the daytime and make nightly sallies in search of food.

The prevention of plague is largely a function of the Federal Health Service. It becomes necessary to inspect all vessels coming from plague infested ports, and to destroy all rats by fumigation before the cargo is landed. When a vessel comes from a port where plague is prevalent it is not allowed to dock, and the cargo is transferred to lighters. Then the ship is fumigated, usually with hydrocyanic acid gas. More important however is the care which should be exercised in the plague port. Here inverted funnels should be placed on the hawsers, and a screen over the hawse pipe. Rats can swim, but rarely long distances, not over a half mile at the most, so that it is safer to load and unload the ship with lighters, the ship being anchored more than a half mile from the land. For more detailed description of the quarantine and disinfection of vessels see the various reports on this subject in the United States Public Health Reports.

There are several other rat-borne diseases of considerable importance, the murine type of typhus fever, acute infectious jaundice, trichinosis, and rat-bite fever. Murine typhus is a relatively mild form of the disease which does not show as high a case fatality rate as classical typhus fever described in Chapter 12.

Acute infectious jaundice, also called Weil's disease, is occasionally seen in sewer workers. It is caused by the *Leptospira icterohemmorrhagiae* the reservoir of which is the common wild rat. The specific organism is excreted in rat feces and may remain alive in sewer water for two or three weeks. Infection is accidental. Weil's disease was common among soldiers in trenches in World War I and believed to be an accidental infection contracted from the large rat population of the trenches.

Rat-bite fever is an uncommon disease believed to be caused by the

Spirillum minus. It is characterized by swelling of the wound caused by the rat bite, generalized fever of a relapsing type, and a characteristic rash of the skin.

The Suppression of Rats: Suppression of the food supply is perhaps the most important measure in the suppression of rats. Because the animals are easily maintained it is the duty of everyone to keep food from rats. All garbage cans should be kept covered at all times. Market places should be cleaned immediately after using. Food should only be carried in freight cars which can be securely closed, and never in gondolas or other open types of cars. Stock cars should be cleaned frequently. No garbage should be allowed on dumps, especially in cities. Cribs for grain in the country should be raised on piers, and inverted funnels placed at the top of the piers. Fine but substantial wire netting should line the cribs for grain. Sewers should be properly constructed. Stables should also house some of the natural enemies of rats mentioned below.

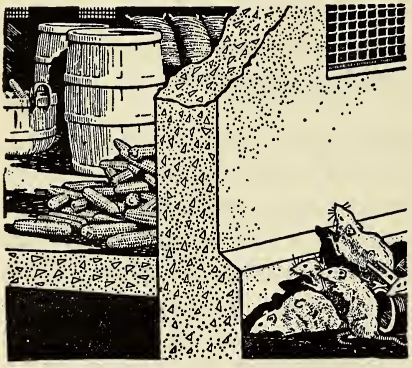

Fig. 66. Rats cannot reach food in rat-proof buildings.
Courtesy Portland Cement Assn.

Suppression of the breeding and living places is the next most important measure. All buildings should be constructed so that no holes or crevasses occur. This usually implies a concrete construction of basements, with a concrete floor. The bases of doors should be covered with metal and the basement or cellar should have metal window frames if possible. Rats are equipped with very sharp chisel-like incisors which are capable of gnawing through soft wood usually used in the construction of doors. They may also make their way through much harder substances such as metal screening and even cement. Rats also congregate around slaughter houses, along water front buildings and markets. Needless to say these buildings should be specially constructed to prevent their entrance.

Among the natural enemies of rats are some of the domestic animals such as dogs and cats. The cat will rarely attack so large an animal

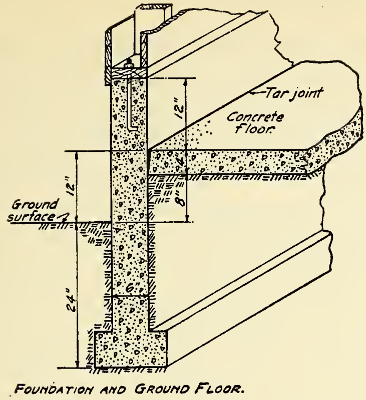

FIG. 67. Buildings where food is to be kept should be made ratproof with concrete foundation and floors.

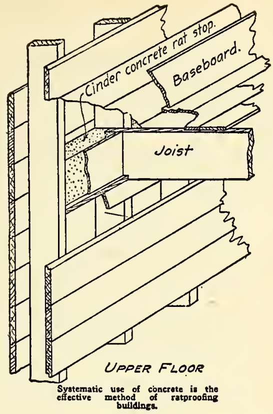

FIG. 68. Upper floors of buildings used for food storage may also be made ratproof.

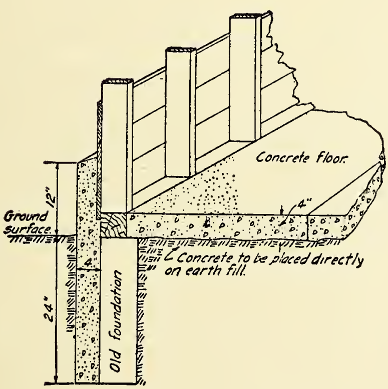

FIG. 69. Old buildings where food and feed are kept may be made ratproof by constructing a concrete wall on the outside or inside of the old foundation.

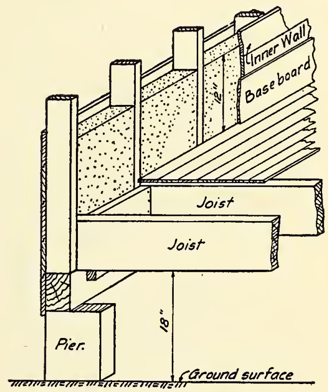

FIG. 70. When buildings are supported on piers they are made ratproof by raising them eighteen inches or more above ground level and by placing concrete between inner and outer walls above the sill.

All drawings courtesy of Portland Cement Assn.

as an adult rat, but does not hesitate to kill the very young rat. Mice however find their real enemy in the cat. Unfortunately most pet cats are too well fed to be very active in the search for rats. Cats are carnivorous animals and can be made good mousers by feeding them on a minimum of meat, thus compelling them to hunt for their fresh meat. Only certain breeds of dogs are good ratters, the terrier being one of the commonest. Undoubtedly as Rosenau has pointed out [4] the indiscriminate killing off of carnivorous birds and animals has been responsible for the increase in rats in the United States. Of the wild animals in this class he lists: the larger hawks, owls, snakes, skunks, foxes, coyotes, weasels, and minks. Many of these are killed by the farmer because they destroy chickens and eggs, but the rat will destroy more of the farmer's chickens and eggs than all of the wild animals put together. Ferrets are semi-domestic animals used for the destruction of rats, and because of their small size and their ability to get into rat burrows are extensively used to combat rats.

It is necessary for man to know the habits of rats, and to make use of this knowledge in rat suppression. It is a familiar fact that the common rat in this country (the brown rat, *Mus norvegicus*) lives in cellars, or in burrows in the ground, or under some building. He sticks fairly close to people for his food supply, his diet being the same as man's. (The white rat is commonly used for feeding experiments because of this fact.) He does not as a rule attack man or other animals but makes his escape with great speed, especially at night. He seems to be better adapted to night wandering than to daylight excursions, and does most of his feeding at night. He is not particularly ferocious except when cornered. He travels close to some object which should be remembered in setting traps, for more rats will be caught when the trap is set against a wall than in the open. Rats use sewers as highways of travel in the city, which explains why we are unconscious of the enormous numbers living close at hand. They are able to climb to a certain extent, but it is only occasionally that rats are able to get into the upper stories of modern buildings. Some species are excellent climbers, the Egyptian or roof rat (*Mus alexandrinus*) and the English black rat (*Mus rattus*) for example. (The black rat has been the principal carrier of plague, and his elimination by the

[4] Rosenau, *op. cit.*, p. 264.

brown rat has had much to do with the elimination of plague in Europe.) Rats become bolder as their numbers increase, probably because of the scarcity of food, and the increased competition for living. A rather exaggerated form of this is to be found in Robert Browning's "The Pied Piper of Hamelin":

Rats!
They fought the dogs and killed the cats,
And bit the babies in the cradles,
And ate the cheeses out of the vats,
And licked the soup from the cooks' own ladles,
Split open the kegs of salted sprats,
Made nests inside men's Sunday hats,
And even spoiled the women's chats
By drowning their speaking
With shrieking and squeaking
In fifty different sharps and flats.

Contrary to popular belief rats very seldom if ever attack sleeping infants. Their ferocity is exaggerated, except when rendered desperate by lack of food. In this country the ground squirrels present more of a public health problem since they have become infected with plague. Their extermination is a biological impossibility. Fortunately many of them are immune to the disease. As in the case of rats fleas may transmit the disease from one squirrel to another.

The sense of smell in rats is very keen, much keener than their eyesight, and explains why trapping them is so difficult. They are able to detect the man smell on traps and will avoid the latter. Consequently traps must be smoked after they have been set, and handled thereafter only with tongs. Almost any bait may be used, but the familiar cheese or bacon seems to be the best.

Certain poisons may be used, but one objectionable feature of them is that practically all rat poisons are also human poisons. Another objection is that poisoned rats die in their nests, and their decomposing bodies generate disagreeable odors. Poison should only be laid out by experts. The same is true of fumigation. Therefore specific directions will be avoided here.

Expert rat shooters can take effective measures against them, especially in warehouses where there is no particular danger of shooting a human. The method par excellence in an empty building is fumigation, carried out by an expert.

Tularemia: This is practically a "new" disease, for it remained unrecognized until about 1911. All of the work in recognizing and scientifically studying the disease has been done by Americans. McCoy in 1911 described a "plague-like disease of rodents" which he first discovered in Tulare County, California.[5] The name "tularemia" is derived from Tulare County, California. Vail, Wherry, Lamb, and Sattler of Cincinnati described the first proved human cases of tularemia (*Bacterium tularense* infection of the eye). It was soon discovered that "deer-fly fever" was the same disease (Francis in 1919 and 1920). Since the disease has become more familiar the number of known cases has been on the increase, because physicians are on the outlook for it.

Tularemia is essentially a disease of wild rodents: Ground squirrels, rabbits and hares, wild rats, and wild mice. The species in which the disease has been found most often are: the ground squirrel (*Citellus beechevi*); the cotton tail rabbit (*Sylvilagus*); the jack rabbit (*Lepus*); and the snowshoe rabbit (*Lepus bairdi*); Man gets the disease in a number of ways: it is common among market men, or housewives, or hunters who dress wild rabbits. In this case it is a wound contamination. The *Pasteurella tularense* enters through the unbroken skin, a cut pre-existing at the time of dressing an infected rabbit, or contaminating a slight wound received while dressing a rabbit. It is transmitted through the bite of an infected fly (*Chrysops discalis*) found principally in Utah and surrounding states. It is also transmitted through the bite of an infected wood tick (*Dermacentor andersoni*). In this species the female transmits the disease to the next generation through the ovum, and the species is a permanent reservoir for the disease.

Tularemia usually expresses itself as a bacteremia, which means that the germ of the disease is present in the blood stream. The symptoms of the disease in man are of several varieties: (1) The lymphatic glands enlarge, and finally ulcerate, discharging pus. (2) The eye becomes infected and is associated with glandular enlargement in the neck. (3) Sometimes the glands enlarge but do not suppurate. (4) Some cases have been confused with typhoid fever, because the symptoms are so similar. The disease does not usually travel from man to man, but

[5] McCoy, G. W. *A Plague-Like Disease of Rodents.* Public Health Bulletin, 43. Washington, U. S. Government Printing Office, 1911.

from rodent to man. By autopsy in man, the principal tissues attacked are the glands in the neck, under the arms, at the elbow, and in the groin, the spleen, the liver, and the lungs. The principal lesion is a killing of the tissue (necrosis). There is a primary ulcer at the site of infection, which shows the characteristic destruction of tissue. When it attacks the eye a conjunctivitis with glandular enlargement is the typical picture. In such a case the *Pasteurella tularense* was rubbed into the eye with a contaminated finger. The onset of the disease is acute with headache, vomiting, chills and fever, aching pains throughout the body, and prostration. There is also pain in the region of the enlarged glands. Fever is the constant symptom. The most striking thing about the disease is the very slow convalescence. This lasts from one to three months or longer. It is a mistaken idea that the disease is not often fatal. Some cases have been rapidly fatal. It is also a mistaken idea that the disease is not particularly severe. It is true that most of the cases do not last over one or two weeks, but some have dragged out to a long period, and in others the complications and sequelae have caused permanent disability. The diagnosis in the animal consists in finding necrosis (which sometimes may be in the form of minute spots) in the spleen, liver, and lymph glands. The disease may be avoided by most people by wearing rubber gloves when dressing rabbits. Inasmuch as the germ is killed by heat, thorough cooking of rabbits destroys the infection in the meat. No one should remove woodticks or horse flies from domestic animals with his bare hands, but should always wear gloves. The antibiotic streptomycin is effective in the treatment of most cases.

Psittacosis: The presence of psittacosis in the United States has called attention to the fact that tropical diseases may often be brought to this country by animals even though our climate is not adapted to the continued maintenance of the disease. It has been known for a long time that parrots often exhibit acute symptoms of psittacosis when imported and many die *en voyage*. The disease is caused by a filtrable virus and characterized in the parrot by loss of appetite, debility, drowsiness, drooping of the wings, and severe diarrhea. Death may be preceded by convulsions and the mortality in these birds is about 50 per cent.

The disease is conveyed to human beings from the feces of the infected parrots, usually those people caring for a parrot suffering with

psittacosis. In man the symptoms are often similar to those of pneumonia. The death rate is high, as a rule over 40 per cent of the people contracting the disease die of it. The infection travels from both parrot to parrot and parrot to man. There are no cases where the disease was conveyed from man to man. The disease has become rare in the United States since the federal embargo against the importation of parrots was instituted.

Glanders: This is a disease principally of horses and mules but readily communicated to man, and is caused by *Malleomyces mallei.* It is communicated directly from the animal to man through infected discharges of the former. Transmission from man to man is not unknown, but the common method is from animal to man. It is characterized by inflammatory nodules on the mucous membrane and the skin, and the common site of its invasion is the nose. On the skin it forms crater-like ulcers which discharge oily material. The mortality rate from this disease is about 50 per cent. This disease is not as prevalent as it was formerly due to the gradual replacement of farm animals with machinery.

Anthrax: This is primarily a disease of lower animals transmissable to man in several ways. It is caused by the *Bacillus anthracis.* The student should be interested in the vivid description of the experiment of Pasteur with an attenuated virus of anthrax.[6]

In man this disease has three general forms according to the part affected: (1) the skin when it is called a malignant ulcer, (2) the lungs called "wool-sorter's disease," (3) the intestines. It is mostly an occupational disease contracted by those who handle hides, especially imported ones. The disease is much more prevalent in Europe and Asia than in America. Occasionally the disease has been seen here in people who have used unsterilized shaving brushes, probably made abroad, or from imported bristles. The prevention of anthrax from this source consists in thoroughly sterilizing shaving brushes by putting them in an autoclave with steam under about 20 pounds of steam pressure for about 30 minutes. The intestinal type may be prevented by eating only Federally inspected meat and cooking that well. Wool-sorter's disease is a real problem in the hide, fur, or wool industries.

The history of the disease is almost the history of the fundamental

[6] Vallery-Radot, Réne, *Life of Pasteur,* Chapter X. New York, McClure, Phillips & Co., 1903.

discoveries in bacteriology. Pollender in 1849 was the first to see a bacterium under the microscope (*Bacillus anthracis,* the causative agent of anthrax). Davaine and Rayer in 1850 first transferred a communicable disease experimentally; this disease was anthrax. Koch in 1875 first grew a bacterium in pure culture and this was the *Bacillus an-*

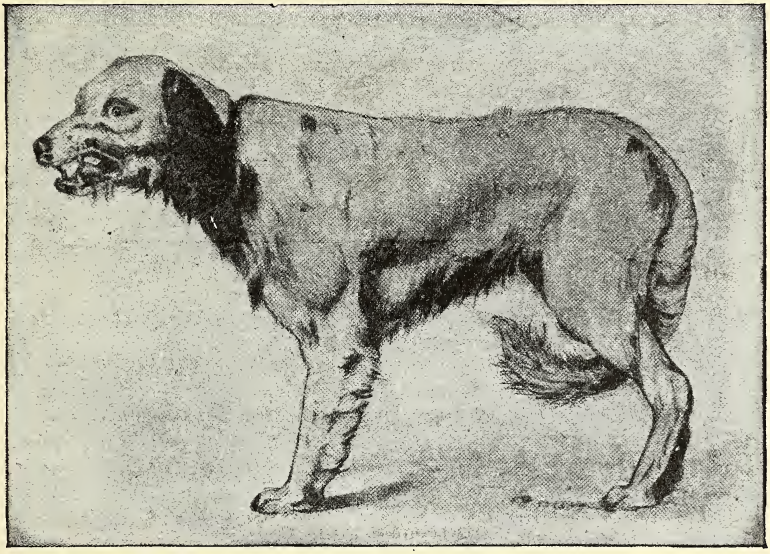

FIG. 71. Dog with rabies, typical attitude.
From Hadley, *Principles of Veterinary Science.* Copyright W. B. Saunders Co.

thracis. Pasteur was the first to inject an attenuated virus demonstrating that an attenuated virus will protect against a disease (anthrax in 1881).

Rabies (*Hydrophobia*): All mammalian animals are susceptible to this disease which is caused by a filtrable virus (see p. 52). It is an acute, specific, rapidly fatal infection communicated from a rabid animal to a susceptible one usually through a wound produced by biting. The infective agent is in the saliva of an infected animal, consequently the licking of an open wound on a man's hand by an infected dog might and sometimes does produce the disease. The virus travels up the nerve trunks to the spinal cord and the brain where it forms characteristic lesions.

The symptoms are pretty much the same in all animals including man. At first there is pain, tingling, throbbing, and numbness in the part which receives the virus. Bites through clothing usually do not produce the disease because the virus is thus wiped off. Bites of the face particularly are likely to cause a rapid course of the disease in humans. However only about one in ten bitten by rabid dogs contracts rabies. All of us remember the amusing "Elegy on the Death of a Mad Dog," by Oliver Goldsmith, which describes what happens in nine out of ten dog bites.

In Islington there was a man,
Of whom the world might say,
That still a godly race he ran,—
Whene'er he went to pray.

And in that town a dog was found,
As many dogs there be,
Both mongrel, puppy, whelp, and hound,
And curs of low degree.

This dog and man at first were friends:
But when a pique began,
The dog, to gain some private ends,
Went mad and bit the man.

The wound it seemed both sore and sad
To every Christian eye;
And while they swore the dog was mad,
They swore the man would die.

But soon a wonder came to light,
That showed the rogues they lied:
The man recovered of the bite,
The dog it was that died.

As far as general symptoms are concerned they are as follows: There is a premonitory stage where a change of disposition is the most noticeable thing. Then there is a period of excitement or delirium when the animal is in the height of his infection. In the dog this is evidenced by excessive activity, the animal sometimes traveling many miles from home, and attacking anything or anyone in its way. The final stage is paralysis and death. Sometimes the course of the disease is so rapid that the last stage is the most notable one when it is called "dumb

rabies." The course of the disease is rather rapid, usually four or five days, rarely more than ten.

Prophylaxis is most important in this disease for the mortality is 100 per cent. No one has ever recovered from rabies. Prophylaxis consists in a number of procedures:

1. Inasmuch as the dog is the common offender all ownerless dogs should be impounded. All others should be either leashed or muzzled whenever they are outside of their owner's property. Pet dogs should be regularly inoculated against rabies by a veterinarian.
2. In insular countries such as England rabies does not exist because a very effective quarantine can be and is maintained against the disease. No one may import a dog without leaving it a long time (six months) in quarantine.
3. The dog bite may be effectively treated with formalin or fuming nitric acid which is applied by means of a glass rod to the very bottom of the wound.
4. The dog which has bitten a person should be tied up and observed for a period of ten days. If the dog has rabies he will die before this time. Because the incubation period in man of rabies is so long, usually more than a month, there is plenty of time to give the Pasteur prophylactic treatment. Exceptions to this rule however occur in those cases where a child has been bitten on the face or neck and consequently near the larger nerve trunks or the brain. In such cases the intensive Pasteur treatment should be given at once. Even this may not save the child.
5. The Pasteur prophylactic treatment consists of using an attenuated virus to produce immunity (see p. 66).

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11

DISEASES USUALLY TRANSMITTED BY FOOD

"Food Poisoning": Food may undergo changes which will render it unfit for use. Putrefaction is the common term applied to such chemical changes in protein food. Pasteur discovered putrefaction to be essentially an anaërobic change brought about by bacteria. In the disintegration of the protein molecule a number of intermediate products are obtained between the proteins and the end products. Some of these substances are poisonous, while others are harmless. The end products of protein disintegration are themselves quite harmless; carbon dioxide, ammonia, the nitrates, sulphuretted hydrogen, methane and other stable compounds. The intermediate substances called "split protein products" seem to be the principal offenders of which the ptomains are the most important. The word ptomain comes from a Greek root meaning "a corpse," indicating that ptomains are found in carcasses. Ptomains however may be found in any article of food coming from animal sources, *e.g.,* cheese. Not all ptomains are poisonous. They are a definite chemical substance obtained by the splitting off of carbon dioxide from the amino acids. Those coming from putrid fish, meat, mushrooms, ice cream, milk, cheese, yeast, and some of the bacteria (*Clostridium tetani, C. welchi, Vibrio cholerae Eberthella typhosa* and the *Salmonella* group) are the most important and most dangerous.

Fermentation is a process very similar in the main to putrefaction as far as cause is concerned. It also is a chemical process brought about by the action of fungi on carbohydrates. The intermediate products of fermentation are not poisonous as are those of protein putrefaction but the end products are inclined to be, especially the higher alcohols and in particular amyl alcohol (fusel oil). All of the alcohols are poisonous, including ethyl alcohol (grain alcohol), and methyl (wood) alcohol which is especially so. Fermentation usually results in more

or less acid formation, acetic, butyric or lactic; alcohols; carbon dioxide, etc. Fermentation usually inhibits putrefaction in mixtures of carbohydrates and proteins.

Foods as Carriers of Disease: Foods carry bacteria which in themselves produce disease more frequently than do the split protein products or the end products of fermentation. In other words foods serve as a culture medium for the growth of certain bacteria, which when ingested produce disease, usually mistaken for "ptomain poisoning." Of the bacteria thus carried the following are the most important:

1. *Staphylococcus aureus* causes a specific type of food poisoning which is probably the most common of all food-borne diseases. This organism, which is found in pimples, boils, infected burns and in some cases of paranasal sinus infection, may contaminate a wide variety of foods including meat, poultry, eggs, cottage cheese and any baked goods containing cream or custard. Food handlers with staphylococcic skin infections or sinus infections should not be allowed to handle foods until they have recovered from such conditions. Symptoms occur in from one to six hours after eating contaminated food and include salivation, nausea, vomiting, cramps and diarrhea but no fever. Prompt recovery is the rule although the patient may be ill for several days.

2. The colon-typhoid group of organisms cause food poisoning by contamination.[1] Some of the organisms come from the meat of cattle ill at the time they were slaughtered while others come from individuals handling the meat or other food. The typhoid organism is the most virulent of the group; it is found occasionally in oysters and shell fish which have been fed in sewage contaminated waters. It is also found in milk and other food contaminated with bacteria on the hands of a patient or carrier.

3. Botulism is a specific intoxication caused by the exotoxin of the *Clostridium botulinum*. It is the most serious of all food infections. The organism itself is saprophytic but under anaërobic conditions, as in a tin can or preserving jar, it develops a particularly virulent toxin, a small amount of which, when ingested, may cause death. The organism is also spore bearing and its spores are widely distributed in nature. The spores are only killed by steam under pressure sufficient to raise the temperature to 248° F. Commercial canning usually provides enough heat to kill the spores of the *Clostridium botulinum* while home canning usually does not. Most cases of botulism come from ingestion of home canned foods which have not been boiled after removing from the can or jar. Specific antitoxins may be inoculated for the relief of the patient but they must be administered before symptoms appear.

[1] These organisms include *Escherichia coli, Eberthella typhosa, Salmonella enteritidis, Salmonella paratyphi, Salmonella schottmuelleri, Salmonella hirschfeldi,* and *Salmonella aertrycke.*

Botulism is prevented by cooking all canned foods, especially those canned at home, for not less than ten minutes after they have been removed from the can. The toxin causing botulism is destroyed by boiling for ten minutes. Proper initial canning is the greatest safeguard.

4. Undulant fever, caused by the *Brucella abortus* and the *Brucella melitensis,* is frequently contracted by ingesting meat or raw milk from cattle or goats suffering from infectious abortion or Malta fever. Cooking the meat and pasteurizing the milk will prevent this disease.

5. Animal parasites, especially the worms, are carried by meat and fish. (See *Meat Inspection* below.)

6. Tuberculosis, formerly carried by meat and milk, is not as great a menace as it once was. (See Chapter 10.)

Preservation and Purification of Foods: Because all food cannot be consumed as soon as it is produced its preservation is of utmost hygienic importance. Historically *canning* was the earliest form of modern food preservation to develop. It was likewise the most efficient. The ideal preservation by canning is obtained when absolutely fresh food is completely sterilized and kept so. Under such circumstances the food will last indefinitely. The first man to hermetically seal boiled infusions of food stuffs was Lazaro Spallanzani (1729–99) of Scandiano in Italy. In attempting to refute the doctrine of Needham concerning spontaneous generation, Spallanzani boiled meat infusions in glass flasks and sealed the slender necks of these flasks with a flame. The infusion was preserved because the bacteria causing decomposition had been killed with heat. Occasionally Spallanzani's infusions would spoil however because he did not realize that spores might germinate. In 1836, Theodore Schwann proved that putrefaction was due to living microorganisms, and later Pasteur showed the origin of these microorganisms to be largely in the air, and that spores were not necessarily killed by a single boiling. It became evident that absolute sterilization could only be obtained in one of two ways: (1) the repeated boiling, or near boiling, of a substance on successive days, in order to give spores a chance to germinate into bacteria and thus ultimately be killed (fractional sterilization) or (2) the use of steam under pressure in an autoclave (marked increase of temperature above boiling). These methods are in common use today in commercial canning. Vegetables, meats, or fish are put into tin cans leaving but a small hole in the top of the can for the escape of steam. The food, can and all, is usually subjected to steam under pressure of 20 to 25

pounds to the square inch. This is sufficient to kill all bacteria and spores. The small hole in the top of the can is finally closed with a drop of solder, and the food has been perfectly preserved. It is absolutely sterile and will keep forever if need be.

Preserving with large quantities of sugar is another method in common use today. Sugar in itself has germicidal properties. Added to this is the necessity of long continued boiling in order to make the final product.

Salting and *Pickling*: The use of salt, vinegar, and spices (germicidal substances) is well adapted to the preservation of certain foods.

Smoking, a very ancient method of food preservation, is efficient, provided it is properly done. Freshly slaughtered meat hung in the smoke of certain hard woods develops within the meat certain complex organic compounds among the simplest of which are small amounts of formaldehyde and cresol. A certain much desired flavor is also developed. Smoked meats are usually impregnated with salt by hanging them in brine solutions before they are smoked. Smoking also has a tendency to dry the foods somewhat.

Drying is another very ancient method of preserving food. Grain, fruit, meat, and even fish may be preserved by drying. The value of drying is enhanced when soaking and boiling are essential to bring the food back to edible form. All bacteria causing food poisoning are killed by drying but the spores of some of them are not. For practical purposes this is not as hazardous as it might seem because the spores themselves do not produce toxins or other deleterious substances. Only bacteria are capable of producing toxins. If the spores can be prevented from germinating and becoming bacteria the food they may be found in is safe. From a practical standpoint all dehydrated food can be made quite safe by cooking and early consumption. Proper refrigeration is very important after dried foods have been cooked in water if the food is to be kept. The hygienic problems concerned with dehydrated food are not many. This is fortunate as such food is usually light in weight and requires little space for packing and shipping.

Chemical preservatives have been used to some extent in the past. Because they have assisted in the fraudulent misrepresentation of food, their use has not been considered good practice. Potassium permanganate has been used to give abnormal red coloring to stale meat. Formaldehyde has been used to preserve milk. The use of chemical

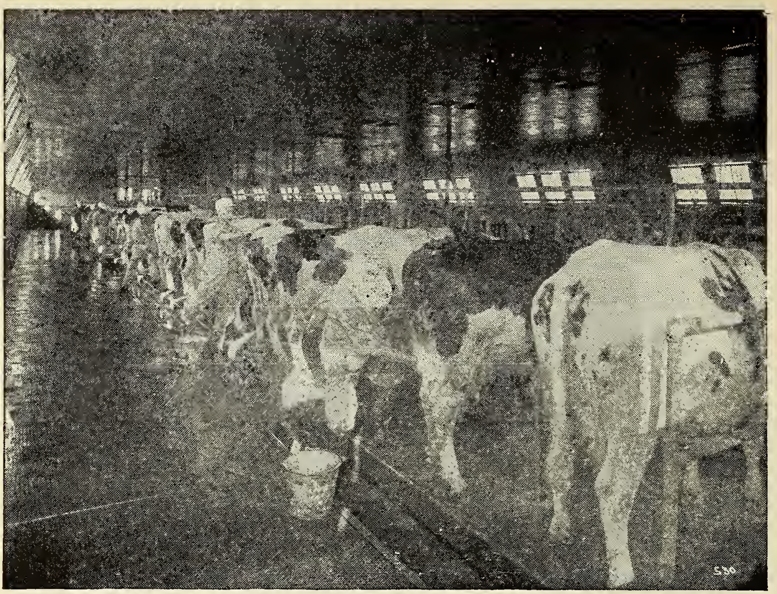

Fig. 72. Cows which supply certified milk. Note the extreme cleanliness of the barn and the "hands" giving the cows a bath preparatory to milking.

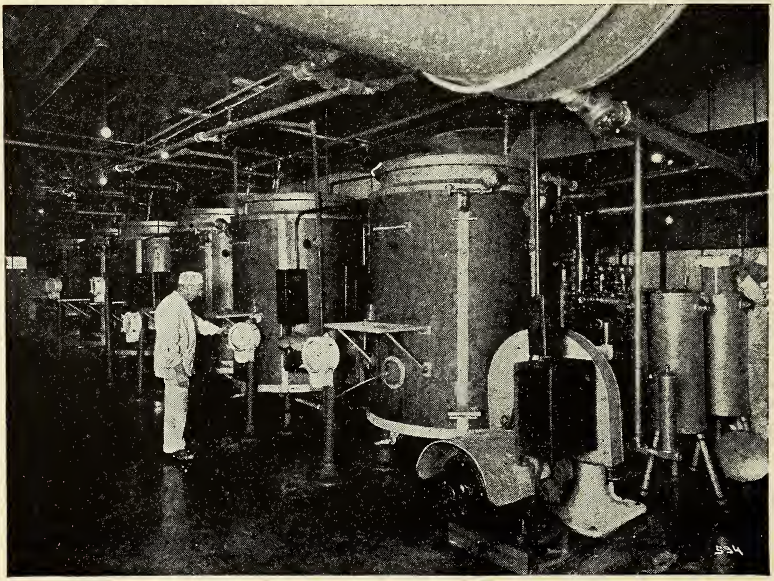

Fig. 73. Pasteurizers in a modern dairy. The attendant is inspecting the temperature chart illustrated in Fig. 74.

Both Courtesy of French-Bauer, Inc., Cincinnati

germicides in meat has been spoken of as "embalming." Indeed the process is not dissimilar to embalming, for formaldehyde is used extensively in this practice. Yet there are some chemical preservatives which seem to do no harm. Benzoic acid and benzoate of soda are instances. The body possesses a special mechanism for disposing of these substances, by changing the benzoic acid and benzoate of soda into hippuric acid, a harmless substance which can be readily excreted by the kidneys.

Cold storage is one of the most important modern methods of food preservation. Because of recent developments in refrigeration low temperatures can be accurately and indefinitely maintained. Bacteria will not grow and multiply at low temperatures. Even the very low temperatures in the modern deep-freeze chests will not kill bacteria but the lower the temperatures at which food is kept in the freezing unit the slower will be the multiplication of harmful substances in it. Some molds will grow well at temperatures just below freezing. The encysted forms of *Trichinella* and the tape worms are usually killed by temperatures from 5-15° if maintained for a week or more.[2] Filtrable viruses, on the other hand, are capable of producing disease when kept at very low temperatures for some weeks or months. The secret of successful food preservation in home deep-freeze units consists in putting only freshly-killed animals or recently-picked vegetables in the freezer and maintaining very low temperatures without interruption. Should the food for any reason thaw it should never be refrozen since bacteria will multiply, spores will probably germinate, and viruses will possibly increase in amount and virulence. Cooking of all food after freezing is essential.

Milk: Cow's milk has become the most important and universal food; its treatment presents a special public health problem. It contains all the ingredients of food: water, inorganic salts, carbohydrates, proteins, fats, and vitamins. As well as being an excellent food for humans it is the same for bacteria—pathogenic and saprophytic. The quality of milk varies and can to some extent be standardized. The common commercial standard is the butter fat content of milk. This should not in any way be considered a hygienic standard. The latter should be as follows:

[2] Rosenau, M. J. *op. cit.*, p. 723.

1. The absence of dirt (manure).
2. The absence of pathogenic bacteria or pathogenic filtrable viruses.
3. The presence of vitamins and other food constituents in a reasonable amount.

The composition of human milk differs somewhat from that of cow's milk. Both are secretions of the mammary gland. There is more protein in cow's milk but less carbohydrate. There is also a difference in the proteins. Cow's milk contains more inorganic salts. No matter how much modification is made in cow's milk it can only approximate woman's milk for infant feeding. Woman's milk is still the best food for the baby.

Certified Milk: This is milk which has been certified by a medical milk commission as meeting a certain standard. This standard varies in different localities, but in the main certified milk implies that the milk is fresh, clean, pure, and unadulterated. Extreme cleanliness is exercised in its production and collection. The dairy hands are healthy and not carriers of any disease. The cattle are examined and tested frequently. They are cleansed thoroughly before milking. Certified milk is usually drawn by mechanical milkers, put into sterilized containers, cooled at 45° F. or less, and kept at that temperature until delivered.

In recent years disease has occasionally been transmitted by certified milk, especially undulant fever. Certified milk is not absolutely safe unless it is pasteurized. When properly pasteurized it is the safest milk possible.

Raw Market Milk: This is a very uncertain article. It is apt to contain organisms of a number of diseases, especially when it is a mixture of milk taken from widely differing sources. More bacteria are found in milk than in any other article of food. Most of these bacteria are harmless however. They come from a number of sources; milk in the udder contains some, the body of the cow adds more, the dust of the stables add some more, and the hands of the milker still more. Almost everything the milk comes in contact with adds some bacteria, which have a tendency to multiply rapidly unless kept at low temperatures. There is no practical method of removing these bacteria except pasteurization. The safe way is to use only pasteurized milk.

Diseases commonly spread by milk are of two general kinds: diseases of cows transmissible to man, and diseases of man accidentally trans-

mitted to man through a contamination of the milk. Of the former bovine tuberculosis, Malta or undulant fever (which are identical), foot and mouth disease, milk sickness, and summer complaint of chil-

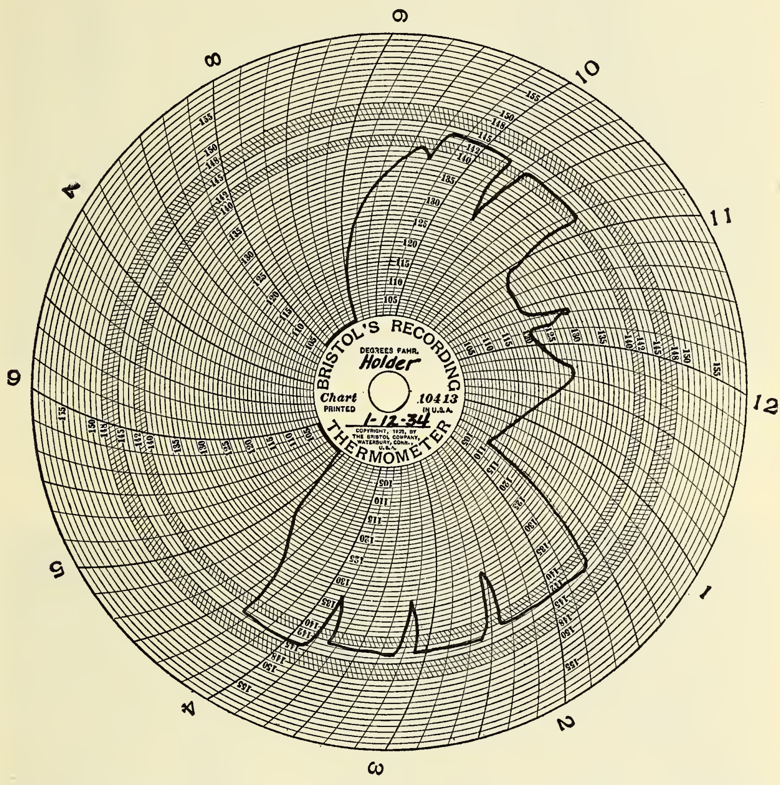

FIG. 74. Temperature chart taken from the "holder" in a large pasteurizing plant. This recording thermometer is used to be certain that the milk in the pasteurizer has reached 142° and remained there for 30 minutes. Six "lots" of milk were pasteurized in this holder on the day in question (see Fig. 73).
Courtesy French-Bauer, Inc.

dren are the most important. Of the diseases of man transmitted by milk due to human handling, human tuberculosis, typhoid (and paratyphoid) fever, scarlet fever, septic sore throat, and diphtheria are the most important. There may be many others occasionally so transmitted.

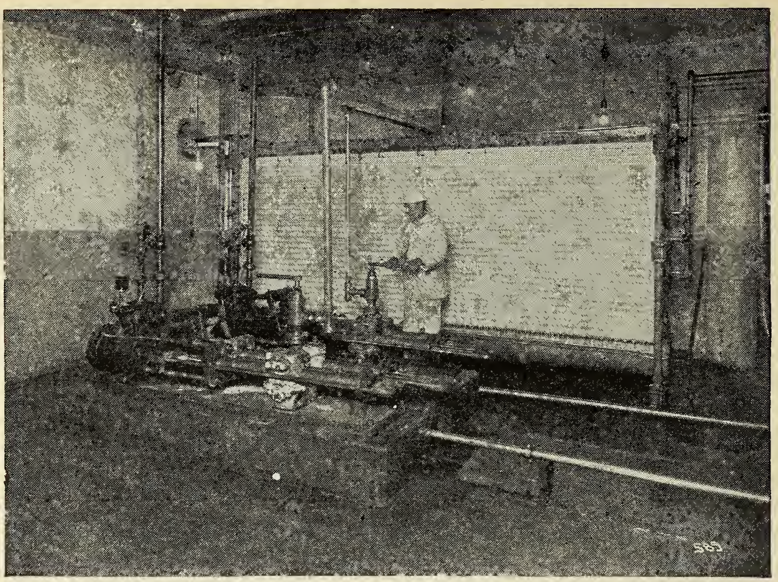

Fig. 75. After milk is pasteurized it is rapidly cooled in the circulating air to prevent objectionable odors and taste. Milk in this illustration is being carried to a homogenizer for the manufacture of ice-cream, and is being pumped to avoid human handling. The floors of this room are kept constantly wet to avoid absorption of dust by the milk.

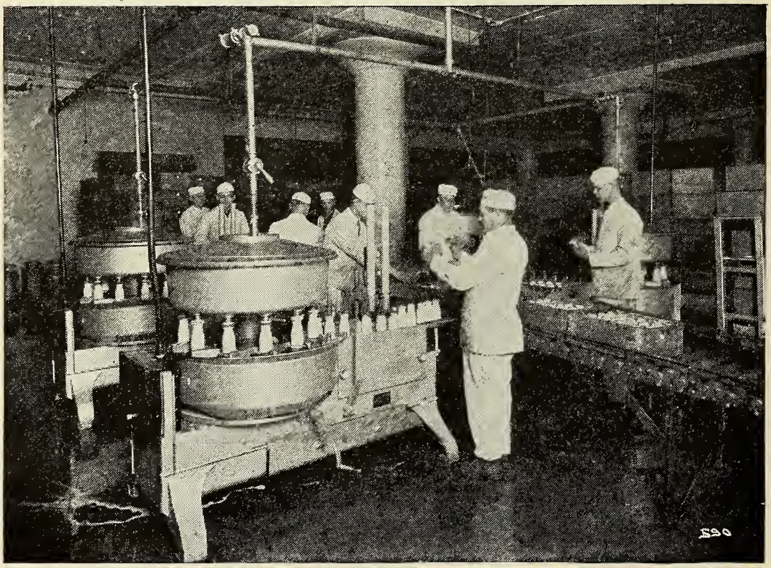

Fig. 76. Sanitary bottling of milk. No human hand has touched this milk since it came from the pasteurizer shown in Fig. 73 and passed over cooling coils similar to those shown in Fig. 75. This is the only sure way of keeping pathogenic bacteria out of the milk.

Both Courtesy of French-Bauer, Inc., Cincinnati

To determine the presence of pathogenic bacteria in raw market milk is a very difficult thing. This usually requires complicated and time-consuming procedures.

Purified Market Milk: The purification of milk for the market now is fairly well standardized in cities at least. This consists of a number of procedures:

1. The tuberculin testing of cattle (see pp. 147-149).
2. Inspection of farms and dairies.
3. The gross bacteriological examinations of milk and the discarding of milk showing too high a total count.
4. The dirt test for milk—passing milk through a cotton filter (see p. 146).
5. Pasteurization. This is essentially the heating of milk to a temperature sufficient to kill pathogenic bacteria but not enough to kill the enzymes in the milk. This heating must be performed rapidly and the milk chilled rapidly to prevent the milk's having a boiled taste. There are two general methods of pasteurization, the "short" and the "long" methods. These are called the "flash" and "hold" methods, respectively. In the "flash" method the milk is heated to 160° F. or higher and held at that point for 15 seconds. If carefully done it is satisfactory but it is not nearly so reliable as the hold method. The latter method consists of heating the milk to 143° Fahrenheit and maintaining it at or above that temperature for at least 30 minutes. (The higher the temperature the shorter the heating period.) The milk is cooled in both cases wtih free access of air in order to prevent objectionable odors. The milk should be aërated by passing it over covered cooling coils just after pasteurization. It should be bottled mechanically.

The small dealer or the farmer may *pasteurize in the final container*. In such a case raw milk is placed in sterilized bottles and heated by sprays of hot water or simply in a water bath. This is really the best method of pasteurization but unfortunately the milk has a peculiar taste.

Milk-Borne Diseases: By far the most important diseases frequently carried by milk are brucellosis (undulant fever), typhoid fever, bovine tuberculosis, and septic sore throat.

Milk is an excellent food for bacteria as well as man and many pathogenic species will remain alive in milk for days. Products derived from milk, such as butter or cheese, may retain pathogenic bacteria for a long time. Each year between 30 and 50 outbreaks of milk-borne diseases are reported to the United States Public Health Service by state and local health authorities.[3]

[3] Andrews, John and Fuchs, A. W. "National Inventory of Needs for Sanitation Facilities," *U. S. Public Health Reports*, v. 59, p. 189, 1944.

All milk-borne disease is preventable. Such practices as testing of cattle for tuberculosis and undulant fever, inspection of dairy hands, supervision of sanitation of the farm and dairy are all important, but

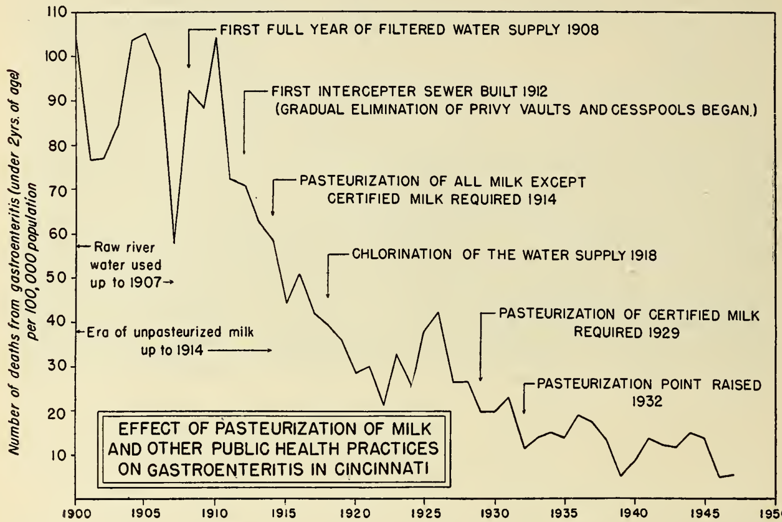

Fig. 77. Infantile diarrheas and dysenteries are often grouped under the general term "gastroenteritis." They have a variety of causes, often undetermined. No doubt many factors enter the picture but health workers usually feature impure water supply, insect vectors (especially flies) and infected milk as the usual modes of transmission of these conditions. In the above chart the effect of certain public health measures directed against gastroenteritis is indicated. After filtration of the water supply a slight improvement in the death rate can be noted. However the installation of a closed sewerage system and the elimination of pit privies, where flies bred in infected material, and the pasteurization of milk caused a greater drop in the death rate than the filtration of the water supply alone. Added chlorination of the city water caused still further improvement. It is impossible to evaluate all these practices but pasteurization of milk undoubtedly played a prominent role, especially after the pasteurization point was raised in 1932.

Data furnished by the Board of Health of the City of Cincinnati

these practices alone will not prevent the outbreaks of diseases carried by milk or its products. As stated above, pasteurization of milk is the only method known for avoiding milk-borne diseases of bovine origin. According to Andrews and Fuchs [4] the risk of contracting disease from

[4] *Ibid.*

raw milk is approximately 50 times as great as from pasteurized milk, even including milk that is only alleged to be "pasteurized milk." These authors point out that pasteurized milk is available in more than 98 per cent of communities over 10,000 population. Only 5 per cent of communities 1,000 to 10,000 population had pasteurized milk when their survey was made. They also found that in 14 states the pasteurization of milk was almost universal practice while in 34 states and Alaska 438 pasteurization plants were needed.

Home pasteurization of milk is not difficult. Those unable to obtain such milk in their communities should follow these directions published by the New York State Department of Health.[5]

1. Place cold or warm water in the bottom or outer section of a double boiler or other deep container.
2. Pour the raw milk in the inner section of the double boiler; put the inner section into the outer container and place over a burner. Do not apply direct heat to the milk.
3. Place a clean thermometer in the milk and stir gently and continuously with a clean spoon. Watch the thermometer and heat the milk quickly to at least 160 degrees F.
4. As soon as the thermometer reads 160 degrees F. remove the milk container and dump the hot water from the outer container.
5. Fill the outer section with cold water or ice in water and replace the inner section in order to cool the milk rapidly to 50 degrees F. or lower.
6. Place the cooled milk in the refrigerator. If the pasteurized milk is transferred to the raw milk bottle or to another container, be absolutely sure to scald such bottle or container with boiling water.

Meat Inspection: The U. S. Department of Agriculture has performed meat inspection for many years. This was instituted originally because of European quarantine against meat coming from the United States. Now all meat shipped in interstate commerce is federally inspected.

One of the principal items in meat inspection is the attempt at discovery of animal parasites in the muscles of the slaughtered animal. The most serious of these parasites is the *Trichinella spiralis* which causes the disease trichinosis. Many carnivorous and omnivorous animals are infested with this parasite but, pork being a popular food, man usually contracts the disease from the ingestion of pork. Trichinosis is usually contracted by eating raw pork in the form of salami

[5] "Emergency Pasteurization of Milk," *Health News*, v. 19, p. 64, 1942.

sausage, mettwurst, Italian style hams, and other similar foods containing pork. The adult parasites live in the intestinal tracts of many mammals, including rats, mice, and other rodents. After copulation the female worm burrows into the wall of the intestine of the host where it lays the embryos within reach of the circulatory system. These embryos migrate to the muscles of the host where they become encysted larvae. The pig acquires its infestation by eating food contaminated by animals with the disease, or by eating rats, mice, and other animals with trichinosis. Rats become contaminated when they eat infected food discarded by the housewife or the abbatoir.

The symptoms of trichinosis in the human vary from mild ones to the most severe. The outcome is usually recovery but death may ensue. The disease is much more widespread than the public realizes. After eating *Trichinella*-infected pork the patient, within 24 to 72 hours, often shows nausea, vomiting, diarrhea or constipation, and abdominal pain. In this stage the case is apt to be diagnosed as food poisoning, intestinal influenza, colitis, appendicitis, and sometimes typhoid fever. After 4 or 5 days the larvae reach the blood stream when the patient shows an irregular fever, swellings (especially under the eyes), conjunctivitis, photophobia, pain in the muscles, sore throat, cough, skin rash, itching of the skin, pleurisy or pneumonia. In this phase the condition is apt to be diagnosed as influenza, rheumatism, arthritis, laryngitis, intercostal neuritis, measles, typhoid fever, asthma (or other allergy), pleurisy, or lobar pneumonia. As the larvae pass through the heart they cause chest pain, rapid heart beat, heart murmur, and abnormal findings in the pulse, and the condition may be diagnosed as myocarditis or endocarditis. If the larvae reach the brain and meninges the patient develops severe headache, malaise, fever, disorientation, delirium, and sometimes coma and death. In this phase the disease is apt to be diagnosed as encephalitis, meningitis, or poliomyelitis. The larvae do not reach the muscles in sufficient concentration to be found there until after the 21st day from the onset of symptoms. The diagnosis of trichinosis is difficult and usually depends upon an examination of the patient's muscle by biopsy. Sometimes larvae can be found in the blood, spinal fluid, and feces. When found the presence of larvae establish the diagnosis, otherwise the disease is only suspected when increase in white cells in the blood (especially eosinophils), fever, and some of the above symptoms are noted. Cer-

tain technical laboratory procedures are used to assist in making the diagnosis.

Federal meat inspection is only practiced on meat shipped in interstate commerce. Most of the larger cities require inspection of meat slaughtered and consumed locally but the small towns rarely enjoy such protection. The obvious conclusion is that pork should never be eaten raw and that all hams, sausages, and other pork foods should be cooked thoroughly. Cooking kills the parasite even in the encysted stage. Discretion should be used in the choice of meat foods such as hamburgers and hot dogs, etc. served outside the home. Trichinosis has been contracted by city dwellers who eat at "hot dog" stands while in the country.

The health problem in trichinosis is not an academic one for about one in every six Americans is infected with trichinosis and there is more than three times as much trichinosis in the United States than is known in the rest of the world.[4]

Meat inspection also attempts to uncover any diseases of cattle, hogs and sheep likely to be carried to man by handling or ingesting the meat of such animals. Most of these diseases are discussed in Chapter 10.

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[6] Stoll, N. R. "This Wormy World." *Journal of Parasitology,* v. 33, p. 1, 1947.

12

DISEASES SPREAD BY INSECTS

Insects belong to the invertebrate group of Arthropoda, and are by far the largest class of animals. The body of a typical insect is encased in a horny substance (*chitin*) which serves as its skeleton. Its name is derived from a Latin word meaning "Cut into," and its three parts, head, thorax, and abdomen are sometimes so narrowly united that the creature seems to be divided into three segments. Its head has four pairs of appendages with which it procures and also masticates food and senses its surroundings. It has (1) a pair of antennae through which its sense perceptions, feeling, and possibly smelling or an analagous sensation, are received. (2) The mandibles are simply hard plates for biting and crushing. (3) The anterior maxillae have a very complicated structure, and probably also contain organs of taste; they are equipped with palpi. (4) Posterior maxillae are also equipped with palpi. Some insects have suctorial mouths, and their mandibles are only slightly developed. In such a case the animal's maxillae have become a proboscis by being protracted into a spiral tube, with a very sharp point. Such an insect is not unlike a hypodermic syringe, with the power of injecting a substance under the skin, and withdrawing fluids therefrom.

In 1893 Theobald Smith did fundamental work in his demonstration that Texas fever of cattle was transmitted by the bite of an infected tick. Since then many diseases have been added to a list, which is constantly growing. We now know that some diseases are always so transmitted and cannot be transmitted any other way, and that in others accidental transmission may take place by the mechanical transfer of a virus or an organism (*mechanical transmission).*

Biological Transmission of Disease: It may be stated as a general law that if a period of incubation is necessary in the insect it indicates that the parasite belongs to the animal kingdom, and passes part of its life cycle within the insect (extrinsic period of incubation). Examples of such biological transmission are malaria and yellow fever.

The insect is the *definitive host,* and man is the *intermediate* host.

The insect host as a rule is not injured by a parasite. The intermediate host in the zoölogical sense is the animal which harbors the asexual cycle of the parasite. The definitive host is the animal which harbors the sexual phase. Thus in malaria, man is the intermediate host and the mosquito the definitive host, because the asexual cycle occurs in the man and the sexual cycle in the mosquito.

It has been noted that only one genus (*Anophelinae*) or sometimes only one species (*Aëdes aegypti*) of insect can transmit a specific disease. True specificity is found in all cases of biological transference, but not always in the mechanical transfer of disease by insects.

Prevention depends upon (1) the disease, (2) the parasite causing the disease, (3) the insect carrying the parasite. Insects are so numerous and breed so easily that the eradication of any species of insect is a biological impossibility, but a reduction in the number of insects is followed by a greater proportionate reduction of cases of the disease carried, and even sometimes an elimination. The geographical distribution of the disease is always more limited than the distribution of the insect host. In migration of insect-borne diseases it is usually the human host and not the insect who carries the disease. In plague, however, the rat may carry the disease with his parasite, the flea, on his back.

All blood-sucking parasites should be considered dangerous. New diseases may make their appearance, for the world is more cosmopolitan than ever, and a new combination of host, insect, and parasite might give rise to a new disease just as these older diseases must have been established at some time in the history of the world. Also there are so many diseases the exact mode of transmission of which is unknown, that the future may prove that the list of insect-borne diseases should be longer than it now is.

Mosquitoes: They differ markedly in their habits:

1. Some may be almost classed as domestic animals (the yellow fever mosquito for example).
2. Some are sylvan or wild mosquitoes (*Culex sollicitans* of the salt marshes of the Atlantic coast) and are seldom found around human habitations. Needless to say these are rarely disease carriers.
3. Some are semi-domestic and may be found both in swamps and around houses (the malaria mosquito).

The life history of a mosquito consists of four stages: (1) The egg or embryo, (2) the larva, (3) the pupa, (4) the imago or adult winged insect. The first three stages are to be found in water only. The domestic mosquitoes will be found breeding in and around houses. The semi-domestic ones prefer swamps, grass-bordered pools, and the margins of lakes and streams.

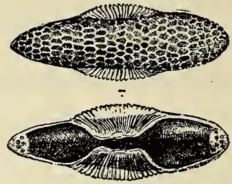

Fig. 78. Anopheles eggs. Greatly magnified.

Male mosquitoes are vegetarians. The females of many species have developed a taste for blood and indeed blood has become indispensable for the full development of their eggs.

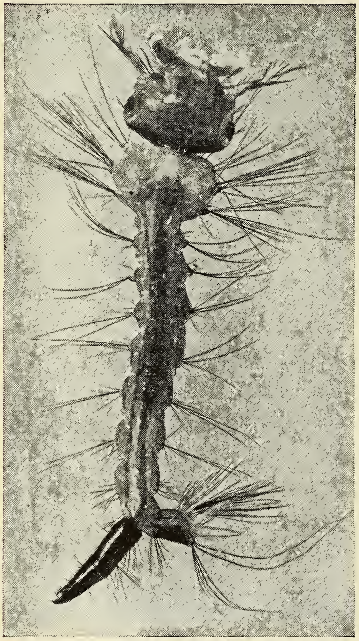

Fig. 79. Mature larva of the mosquito, *Culex quinquefasciatus*, magnified.

Both Courtesy Bureau of Entomology, U. S. Dept. of Agriculture

The mosquito usually lays her eggs on the surface of the water. In a day or two the eggs hatch into *larvae* or "wiggle tails." They may search for food but they must make frequent trips to the surface for air. Some species rest and feed at the surface of the water (*Anopheles*). The larval stage lasts about one week, and is then transformed into a curiously shaped creature known as the *pupa*. This stage has no mouth and does not feed. It breathes through two trumpet-shaped tubes projecting from the dorsum of the thorax. This stage lasts from two to three days and is terminated by the emergence of the adult winged insect (*imago*), from its pupal case through a rent in the region of the breathing tubes. Warmth favors and cold retards development.

Malaria Mosquito: So far as known no other mosquito but the *Anopheles* carries malaria. Man is the intermediate host and the mosquito the definitive host. No other natural transmission of malaria is possible than that of the bite of a mosquito.

FIG. 80. Adult mosquito emerging from the puparium after completing its under-water stages of growth, magnified.

From Overton, *The Health Officer.* Copyright W. B. Saunders Co.

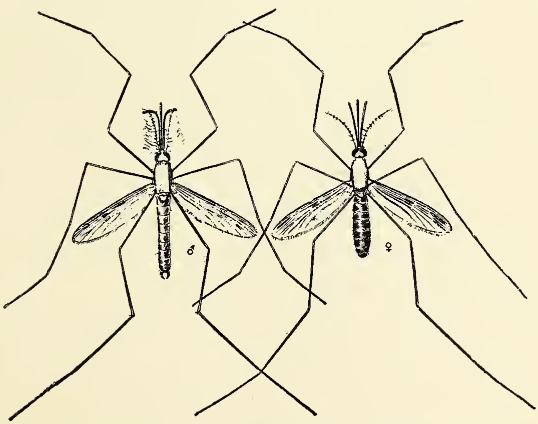

FIG. 81. *Anopheles quadrimaculatus.* Greatly magnified. Male and female.

Courtesy of the Bureau of Entomology, U. S. Dept. of Agriculture

At least 25 species of the *Anophelinae* carry malaria but in the United States the *Anopheles quadrimaculatus* has been the most important vector. The salient points of this genus of mosquito are: it is brownish and rather large. It is nocturnal in its habits, semi-domestic, and breeds in swamps, open ponds, puddles, and any natural collection of water.

The mosquito becomes infected upon drinking the blood of a malarial patient or carrier. After an extrinsic incubation period of 12 days the malarial parasites appear in the salivary glands of the insect. Malaria cannot be transmitted until this extrinsic period of incubation has passed. The mosquito then is infective for man during its whole lifetime. The parasite, however, will only develop in the mosquito in warm weather which explains the comparative absence of the disease in northern climates.

Malaria: This disease is as old as history. At the time of the siege of Troy by the Greeks the presence of malaria in the Greek troops is said to have been the cause of their vacillation before the walls of Troy. When Hannibal invaded Italy and his forces approached the pestilential regions near Rome his losses in illness and death from malaria were so great that he did not attempt the conquest of Rome itself. It is believed by scholars that this disease had much to do with the decline and fall of both ancient Greek and Roman cultures. In the American Revolution, Lord Cornwallis' troops were stricken with malaria in their southern campaign and finally surrendered. In the U. S. Civil War, malaria became so prevalent in the Confederate army and quinine so scarce there that the disease had much to do with the collapse of Confederate resistance to Union invasion. In World War II, malaria was so prevalent in our troops in the South Pacific that many veterans returned from there still have chronic malaria. There has never been a war fought in tropical or subtropical regions that malaria was not common among the soldiers.

It is estimated that 800 million people, or approximately one-third of the world's population, suffer from acute or chronic malaria. The estimated number of deaths from this disease is 2 million yearly. In some tropical areas 90 per cent of all deaths are due to malaria.

In 1630, Don Lopez of Ecuador cured the Countess of Cinchon of malaria with the bark of a Peruvian tree. Since that time this bark has been known as chinchona bark and its purified extract is called

quinine. This drug was first prepared by two Frenchmen, Pelletier and Caventou, in 1820.

In 1884, Alphonse Lavaran, a French army surgeon, discovered that malaria was transmitted by the bite of a mosquito. In 1895 Sir Ronald Ross observed the parasite in the body of a mosquito. He noticed that when a mosquito fed on a person suffering from malaria the semilunar cells in the abdomen of the insect developed into black splotches, indicating the multiplication of the parasites within the body of the insect. Shortly thereafter Baptista Grassi, an Italian scientist, discovered that only the *Anopheles* contained these malarial parasites.

In 1930, a group of German scientists (Schuleman and his associates) developed atabrine as an antimalarial drug. This substance has been very effective in the prevention and treatment of malaria. An average acute case of the disease can usually be cured by approximately one gram of the drug (in divided doses) in about a week whereas about eight weeks of treatment are usually required for the cure or arrest by the use of quinine.

Malaria is an infectious, febrile disease caused by several species of protozoa of the genus *Plasmodium*. In man the disease is produced by an invasion of the blood by the *P. vivax, P. falciparium,*[1] *P. malariae,* or *P. ovale*. The disease is transmitted from the bite of an infected mosquito and not from person to person except in a few instances where the donor in a blood transfusion has transmitted the disease. Many hospitals will not transfuse into a patient the blood of a World War II veterans who were in the South Pacific Theater.

The most common variety in the United States is *P. vivax* infection, also called tertian malaria. About ten days after an infection has been acquired the parasite appears in the red blood cells of the host as a ring-shaped structure (see Fig. 18,b). The parasite enlarges and its nucleus divides (segmentation). At the end of 48 hours the red blood cell containing the parasite is a mere membrane and the parasite has consumed all of the cell's hemoglobin. The membrane ruptures and the daughter cells (*merozoites*), which are released, invade new blood cells and the cycle begins again. At the time of segmentation of the parasite the patient has chills, fever, and general malaise. The

[1] Pronounced fal-sip'-arum and named from the Latin word for sickle. The parasites of this variety in the red blood cells of man are sickel-shaped.

fever may rise to 106° and sometimes 107°. After the fever has lasted for several hours the patient develops marked sweating, his temperature falls to normal, and he has a sense of comparative well-being. In 48 hours he again becomes chilly, develops a high fever followed by sweating and recovery. The chills of the patient are usually very severe and last about an hour. His teeth chatter and the bed shakes. During the acute attack he usually has a severe headache. In the milder cases an individual can sometimes follow his usual occupation as he may be acutely ill for only a few hours every other day.

Similar symptoms are seen in *P. malariae* infection (also called quartan malaria) except that the cycle is repeated every 72 hours. *P. falciparum* infection (also called Aestivo-autumnal malaria) is a serious type of the disease with more severe and longer-lasting symptoms and a high mortality rate. Mixed infections are sometimes seen and several types of the *Plasmodium* organism may be recovered from the same patient. In severe cases the chills and fever may be almost continuous; this indicates a multiple infection, or a mixed infection. That is, the patient was bitten by several malarial mosquitoes at different times and the various cycles are superimposed on each other or both tertian and quartan malaria may be present in the same person.

One attack of malaria predisposes to another. Mixed infections are numerous and carriers are far more numerous than cases. In many cases quinine or atabrine will not cure the carrier, but will usually cure the patient.

Patients with tertian or quartan malaria rarely die of the disease but they often become chronic carriers and are able to infect mosquitoes. The incidence of endemic malaria has not increased noticeably in the United States since the return of veterans from the tropics, and authorities feel that there is no particular danger of spread of the disease in the temperate regions of this country.

The Prevention of Malaria: The only successful method in malaria prevention is the extermination of the *Anopheles* mosquito. This is a difficult problem because the mosquito is widespread in its geographic distribution and breeds in swamps or any natural collection of water, often far from human habitation. It can travel a mile or more by its own efforts or be carried many miles in a high wind. Any reduction in mosquito population in a malarial district is followed by a greater

proportionate reduction in new cases of the disease. The draining or filling of swamps is a permanent measure, if it can be accomplished. If it cannot be accomplished, various oils have been used on the surface of stagnant water to suppress the larvae. DDT discussed below is an excellent larvacide and is usually added to the oil. The stocking of ponds with fish will suppress larvae as they serve as a food supply for the fish. The edges of such ponds should be cleared of vegetation in order that the fish may have access to all parts of the water. Mosquitoes do not lay their eggs on fast moving water and any device that will eliminate eddies along moving streams and speed up the current of the water will help suppress the insect. In the tropics the clearing of the jungle will expose adult mosquitoes to a hot sun which will destroy most of them. If crude oil, creosote, and DDT are used to suppress larva development they should be started as early in the spring as possible and repeated frequently during a warm season, where seasons exist. In tropical countries periodic applications the year around are necessary for proper results. Broken bottles, crockery, or discarded cooking utensils on dumps should be buried to avoid accumulation of rain water. Sagging house gutters should be repaired and cisterns should be covered. All ponds around human habitations should be well stocked with fish, as stated above.

The malarial mosquito feeds on the individual mostly at night. The screening of houses and the use of mosquito bars is very important in malarial regions. In fact the screening of houses is the most important single item in personal prophylaxis. Rosenau states that he was able to demonstrate that a yellow fever mosquito could pass through a metal wire screen containing 16 strands to the inch.[2] This is the fineness of "good" screens used in most houses. This mosquito cannot pass through a screen of 19 strands to the inch. In localities where malaria is common it is desirable to have a screened vestibule with two doors in order that the individual entering the house does not present too wide an opening for the entrance of mosquitoes to the house. It is also well to have a whisk broom hanging in the screened vestibule to brush insects off the clothes before entering. An electric fan with the current of air directed outwards placed before the door will help in preventing the entrance of mosquitoes.

[2] Roseneau, *Preventive Medicine,* p. 211.

The treatment of all cases of malaria in a community will reduce its incidence and prevent many new cases. The use of atabrine as a prophylactic is of considerable value. The drug plasmoquin would probably be of more value were it not so toxic to some people. Experience in World War II indicated that such prophylaxis was well worth while. When the invasion of Guadalcanal was accomplished there was no atabrine or quinine available and the marines concerned in the invasion suffered great losses from malaria. When the supply of atabrine was adequate for prophylactic and curative use the incidence of malaria declined sharply.

The most effective insecticides for mosquitoes are DDT, volatile oils, and pyrethrum which are discussed below.

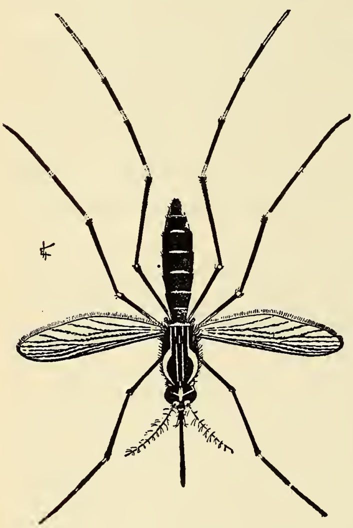

Fig. 82. *Aëdes aegypti,* yellow fever mosquito, female. Greatly enlarged. Courtesy Bureau of Entomology, U. S. Dept. of Agriculture

The Yellow-Fever Mosquito: The mosquito has a world wide distribution, from 38° north to 38° south latitudes. In the United States they are very prevalent south of the Potomac and along the Gulf of Mexico.

As has been said the mosquito is domestic and breeds by preference in or around dwellings. It does not breed in swamps or marshes. Furthermore, it does not fly of its own volition very far from its place of birth or adoption.

The yellow fever mosquito (called *Aëdes aegypti)* is a grayish mosquito of average size, with beautiful glistening silver white markings on the back of its thorax, which are lyre-shaped, silver white spots on the sides of the thorax, and white lines at each tarsal joint and also on the palpi. (See Fig. 82).

The eggs show a remarkable power of resistance, and will withstand freezing, drying, and other unfavorable environment. The larva ("wiggle-tail") breathes through a respiratory siphon as does the malaria mosquito. The pupa also lives as does the pupa of the malaria mos-

quito. Under the most favorable condtions about 9 days is necessary for the production of an adult mosquito from an egg.

It is a notable fact that yellow fever is conveyed but a very short distance, perhaps just across the street. Especially is it true that the mosquito will not travel over a very small body of water. Consequently ships may be anchored just off the coast of a yellow-fever infested country without those on board getting the disease.

Yellow Fever: The Yellow Fever Commission of the United States Army in 1900 showed that the transmission of yellow fever is concerned with the bite of an infected mosquito, this mosquito getting its infection from a previously infected human patient. This commission was composed of Drs. Walter Reed, James Carroll, Jesse W. Lazear, and Aristides Agramonte. Previously Dr. Carlos J. Finlay expressed the belief that the tiger mosquito was the carrier of yellow fever, but most people believed that the disease was transmitted by direct contact or by inanimate objects such as clothing worn by a patient. Dr. Henry Carter of the United States Public Health Service had noticed that an extrinsic period of incubation was necessary for cases of yellow fever to be spread from person to person and told Walter Reed of his discoveries. Reed then suspected a mosquito host. An experimental camp was set up in Cuba. Doctor Carroll was the first of a group of courageous men to offer himself for human experimentation. He allowed a mosquito suspected of carrying yellow fever to feed upon him. He developed yellow fever and almost died. The next volunteer was Private Willian Dean, U.S.A., known as "X.Y." in the original reports. He also became sick with yellow fever but recovered. Doctor Jesse Lazear while working in the yellow fever ward of the hospital on September 13, 1900, allowed a mosquito to bite him on the finger, the outcome of which was fatal and he died on September 25, 1900. After his death the experimental camp was called Camp Lazear.

General Leonard Wood, in command in Cuba, called for volunteers to submit to human experimentation. Private John R. Kissinger and civilian clerk John J. Moran, both of Ohio, were the first to offer themselves without reward. Walter Reed said to them, "Gentlemen, I salute you," and touched his cap. Kissinger developed yellow fever after being bitten by a suspected mosquito, but Moran did not. Five Spanish immigrants were paid $200 each and four of them developed yellow fever. To prove that bed clothing did not transmit yellow fever,

three volunteers, Dr. R. P. Cooke, Private Warren G. Jernegan, and Private Levi E. Folk slept for twenty nights in a dark, damp room in bed clothing used by yellow fever patients without contracting the disease. To show that the air did not transmit the disease a room was constructed and divided by a screen partition. It was effectively screened and inhabited for a time by volunteers to show that it was a healthy place. The volunteers remained well. Then John Moran and a swarm of yellow-fever mosquitoes inhabited one side of the partition while two other men lived on the other side. This time Moran contracted yellow fever while the others remained well. When the mosquitoes were removed the side in which Moran stayed again became a healthy place. Finally the others, who had remained well, were inoculated with yellow-fever virus and contracted the disease; thus proving that they were not immune. A nurse, Miss Clara Maas, also a volunteer in the experiments, is a forgotten heroine. She died of yellow fever during this investigation. Her name does not appear in any of the official reports. (For a complete list of the participants and full particulars of the yellow-fever experiment in Cuba see Surgeon-General Ireland's article in the *Military Surgeon,* February 1929).

The mosquito becomes infected by sucking the blood of a yellow-fever patient, *in the first three days of the illness.* The extrinsic period of incubation is about 12 days, and the mosquito once becoming infected remains so for the rest of its life, which may be for many months. One of Dr. Reed's mosquitoes was called "Her Ladyship" because she had figured so prominently in so many experiments. The disease can be produced experimentally by the injection of the blood of an infected person, sick less than three days with yellow fever, into a well individual.

Immunity: There is no racial immunity, and no natural immunity from the disease. Some people in yellow-fever districts during epidemics seem to be immune, but this is partly explained by the fact that sometimes yellow fever is extremely mild, and often missed in infancy and childhood, and that one attack of the disease confers a life-long immunity on the individual. Therefore, many of the individuals who escape the disease when exposed have an immunity acquired early in life.

Prevention. The prevention or suppression of yellow fever may be attained in either of its hosts, man or insect. If every person develop-

ing yellow fever be immediately isolated, and protected from the *Aëdes aegypti* mosquito, yellow fever would inevitably cease. The elimination of the *Aëdes* mosquito would give the same result. Usually both methods of attack are used, as follows: (1) Screening cases of yellow fever and all suspected cases of yellow fever, with screens of 19 meshes to the inch. (2) The destruction of infected insects. (3) The suppression of the *Aëdes* through the control of their breeding places.

Yellow fever no longer exists in the United States and airplanes coming from Africa or Brazil are carefully inspected for mosquitoes. Infected mosquitoes could reintroduce the disease in this country.

PREVENTION OF MALARIA AND YELLOW FEVER CONTRASTED

Malaria	*Yellow Fever*
Hard to get rid of *Anopheles.*	Easier to get rid of *Aëdes.*
Semi-domestic—wide range of breeding places.	Domestic—breeding places close at hand.
May travel distances.	Never travel distances.
Human host infective for mosquito as long as plasmodium is present in blood (long time).	Human host infective for mosquito only three days.
Quinine an effective prophylactic.	No known prophylactic drug, but protective inoculation available.

International Studies in Yellow Fever. Much interest has existed in the problem of yellow fever, especially in Africa and Brazil, where the disease has remained unrecognized or neglected for a long time. In November, 1932, a conference was held at Cape Town, South Africa, attended by officials from many of the political subdivisions in Africa.[3] The Rockefeller Foundation, U.S.A., was also represented. This conference brought out that yellow fever is endemic over a large section of western Africa. The disease, however, is inclined to be mild there, somewhat like measles in our own country. Also like measles, children are the ones most commonly affected, and inasmuch as one attack, no matter how mild it may be, confers a life-long immunity, a large proportion of the adult population is immune to the disease. Doctor W. A. Sawyer,[4] Associate Director of the International Division of the

[3] League of Nations, *Quarterly Bulletin of the Health Organization,* v. II, no. 1, p. 4, March, 1933.

[4] Sawyer, W. A., "The Present Knowledge of Yellow Fever as It Relates to the

Rockefeller Foundation, used a test devised by Dr. Max Theiler, a test employing monkeys at first, and later, white mice to determine the susceptibility of individuals to yellow fever. This test, called a "protection test," was given to a large number of people in Africa for epidemiological studies. It is made by extracting a small amount of blood from them, mixing the serum from the blood with a suspension of mouse brain containing the fixed yellow-fever virus and injecting into mice. Susceptible white mice are anesthetized with ether. Each mouse is given an intracranial injection of a 2 per cent sterile starch solution to localize the virus in the brain, and an intraperitoneal injection of the serum-virus mixture. Six mice are so injected, and if four or five of the six die in from 5 to 10 days they are assumed to have died of yellow fever, and that the subject from whom the blood has been taken is not immune from that disease. If, on the other hand, all of the mice survive, or only one dies, the subject is assumed to be immune from yellow fever, and his blood serum to have protective power. Intermediate results are considered inconclusive, and require repetition of the test. The tests are controlled by injecting mice with known immune or non-immune sera.[5] These experiments are the basis for the laboratory diagnosis of yellow fever at the present time (1949).

Protective Inoculation for Yellow Fever: Following the successful use of the protective test of Theiler, Dr. Sawyer and his associates[6] devised a method of inoculation of susceptible individuals against yellow fever. This protective inoculation promises to prevent such tragedies as occurred in the death of Dr. Noguchi, who lost his life in 1928 while studying yellow fever in Africa. The method of inoculation consists in injecting a dried mixture of living yellow fever virus, fixed for mice, and human immune blood serum. Applying the protection test described above to such immunized human subjects it was found that they rapidly acquired an active immunity which lasted

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Problem in Africa." *Quarterly Bulletin of the Health Organization of the League of Nations,* v. II, p. 29, March, 1933.

Hughes, T. P., and Sawyer, W. A. "Significance of Immunity Tests in Epidemiology as Illustrated in Yellow Fever." *Journal of the American Medical Association,* v. 99, p. 978, Sept. 17, 1932.

[5] Sawyer and Lloyd, *Journal of Experimental Medicine,* v. 54, p. 533, 1931.

[6] Sawyer, Kitchen, and Lloyd, "Vaccination against Yellow Fever with Immune Sera and Virus Fixed for Mice." *Journal of Experimental Medicine,* v. 55, p. 945, June, 1932.

some time (the period of observation and testing lasted over six years.)

Dengue. This is a disease popularly called "break-bone fever" in the South, on account of the pains in the joints, and "dandy fever" because of the stiff and dandified gait. It is prevalent only in the tropical, and subtropical countries where the *Aëdes* mosquitoes are found. Although the mortality is very slight, it often leaves the body in a weakened, and crippled condition, for a long time. Its importance lies in the fact, that its epidemiology and symptomatology parallels yellow fever to a remarkable extent. It greatly resembles influenza in the following ways: (1) Epidemics start with explosive violence. (2) Almost everyone attacked in a very short time. (3) The painful symptoms are similar.

No other disease attacks so many people in so short a time. There is no permanent immunity produced in an attack of dengue. The cause of the disease is not known. The insect vector of dengue fever is the yellow fever mosquito (*Aëdes aegypti*).

Filariasis: The filarial parasites are the cause of a group of disease found mostly in Africa and the South Pacific. The common forms are Bancroft's filariasis, caused by *Wuchereria bancrofti,* and Malayan filariasis, caused by *W. malayi*. The former is carried by the *Culex* mosquito and the latter by the *Mansoniae* and *Anopheles* mosquitoes. Filariasis is characterized by lymphatic swellings in various parts of the body: the legs (elephantiasis), groin, scrotum, and sometimes the upper part. The larval forms of the worms, called microfilariae, are found in the circulating blood. Some veterans of World War II have contracted the disease which is a rather benign condition and self limited.

Flies: The true flies have but two wings, that is they are the order of *diptera*. They comprise an enormous number of species, all of which vary in their likes and habits. The growth of a generation from the egg to the adult requires from 10 to 14 days. Their multiplication is rapid, and the logical time to begin fly suppression is in the spring.

The Transmission of Disease. This is of two types:

1. The biting flies, such as the *tsetse* flies, which transmit sleeping sickness, inoculate the infective agent directly into the body by piercing the skin with their mouth parts.
2. Some flies do not bite but transfer disease by mechanical transfer of

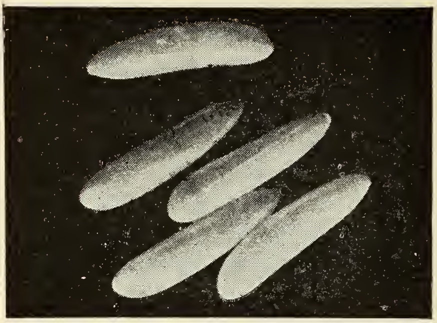

FIG. 83. Eggs of the house fly *(Musca domestica)* greatly enlarged.

FIG. 85. Larva of the house fly greatly enlarged.

Both Courtesy Bureau of Entomology, U. S. Dept. of Agriculture

FIG. 84. A house fly, magnified, showing the hairs on its body.

From Overton, *The Health Officer*. Copyright W. B. Saunders Co.

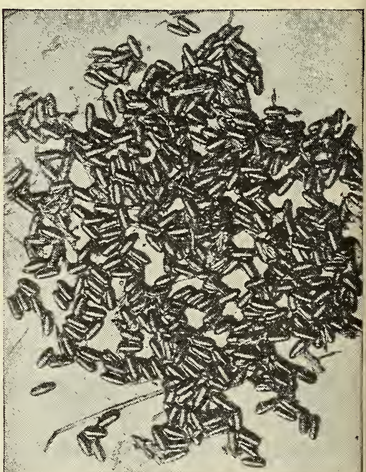

FIG. 86. Puparia of the house fly greatly enlarged.

Courtesy of the Bureau of Entomology, U. S. Dept. of Agriculture

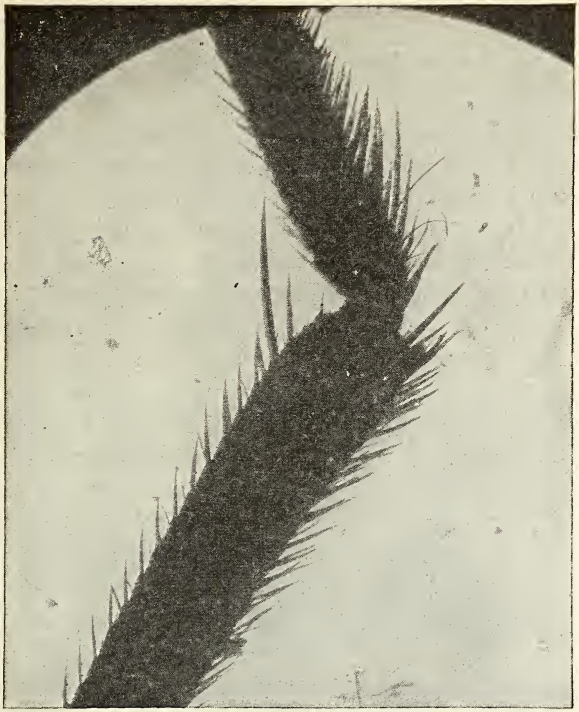

FIG. 87. A fly's leg, showing the coarse hairs with which it is covered. Magnified fifty times.

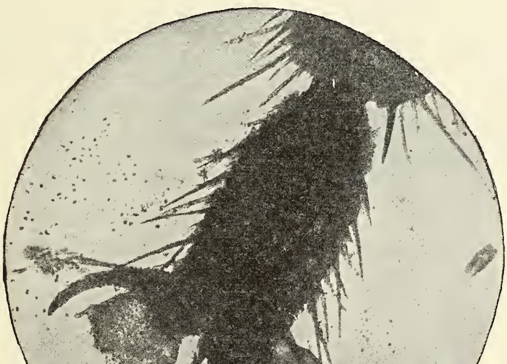

FIG. 88. House fly's foot magnified 100 times.
Both from Overton, *The Health Officer*. Copyright W. B. Saunders Co.

bacteria on the surface of their bodies and wings and legs. They may also regurgitate infective material.

Life History of the House Fly, Musca domestica: The eggs of the common house fly are laid in masses, in garbage or manure, as a rule. Each mass is the result of a number of depositions by several female flies. In 6 to 8 hours the eggs hatch into larvae (maggots), which grow rapidly and are fully developed in 4 or 5 days. Each larva then becomes a pupa in a dark brown hard case called the puparium. In 5 days more the pupal case opens and the adult fly emerges. It takes about 10 days from egg to adult in warm weather. Apparently the eggs, larvae, and pupae have the power to hibernate. It is possible for them to continue breeding throughout the winter in heated houses. The chief breeding places of common house flies is in horse manure, in fermenting vegetable and putrefying animal matter. They especially prefer the carcasses of dead animals. The accumulation of filth encourages fly breeding. The larvae leave the moist material for a dark, dry spot.

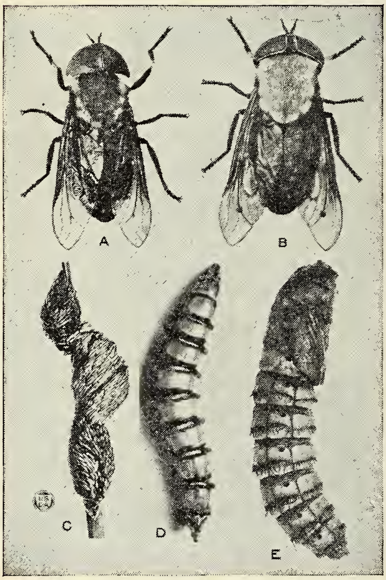

Fig. 89. Various stages of the horse fly (*Tabanus punctifer*) greatly enlarged. Courtesy Bureau of Entomology, U. S. Dept. of Agriculture

Life History of the Biting Stable Fly (Stomoxys calcitrans): The biting stable fly is very similar to the house fly in its life history and in appearance during the preparatory stages but develops more slowly, requiring about a month to complete a life cycle. The adult flies are much like those of the house flies except that they have a sharp needle-like proboscis. They feed exclusively on mammalian blood. They bite persons much less frequently than horses and cattle, but are of importance on account of their possible relation to transmitting infections.

Flies as Mechanical Carriers of Infection: Joseph Leidy in 1864 thought that hospital gangrene occurring during the Civil War was spread by the house fly. It is now known that typhoid fever and other infections of intestinal origin may be transmitted in the same way. During the Spanish-American War it was definitely shown that flies carried typhoid fever. In a well-sewered city, however, the danger from infection from typhoid-bearing flies is not to be feared. Smallpox, measles, scarlet fever, and other exanthematous disease may be transmitted by flies. Maggots have even been found breeding in open smallpox lesions.

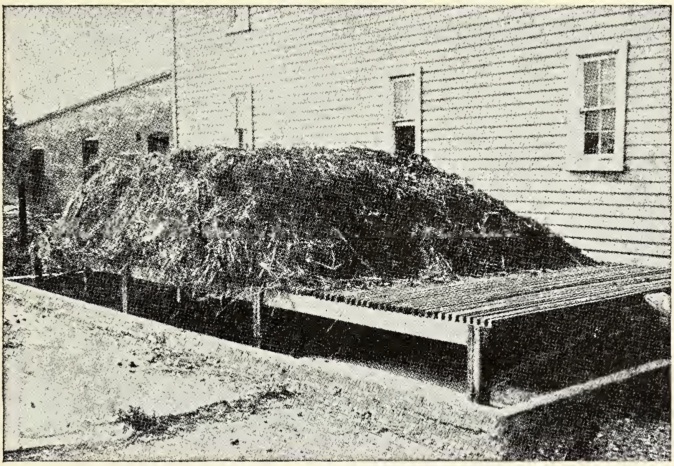

FIG. 90. A properly constructed manure platform. Larvae and pupae of flies migrate to the bottom of the manure pile, drop through the slats of the platform to the concrete beneath. From here they are removed and burned.

L. O. Howard, *The House Fly—Carrier of Disease.* Courtesy *Hygeia,* Chicago

Fly Suppression: This seems to be a difficult practical problem although by simple cleanliness some cities, *e.g.,* New York, are comparatively free from them. Covering garbage cans must be enforced and in city stables horse manure must be kept properly covered and removed at least once a week. Manure should be kept in dark places because flies prefer the light. Elevating piles of manure on platforms and sweeping out the migrating larvae daily will help control the

breeding of flies. Screened manure bins will prevent the deposition of eggs by the female.

The adult animal is harder to eliminate than the larva. Sticky fly paper, fly traps, electric fans and other well-known measures will help dispose of a certain number of flies but all these measures are tentative and attack the problem at the wrong end. Fortunately the flies, themselves, are attacked by a number of diseases. Their natural enemies are the spider, the house centipede, the common garden toad, some lizards, and a few birds. DDT is effective in destroying adult flies as well as their larvae. It is best administered in a volatile oil spray.

African Sleeping Sickness: This disease has always been limited to tropical Africa. The disease is characterized by two stages: the first, by regular fever, swelling of the glands, erythematous rash and localized edema (or swellings); the second stage by slowly increasing lethargy, and other morbid, nervous symptoms. It usually terminates in death. Many instances of fatal "homesickness" in Negroes during the slave trade are now believed to have been due to this disease. The trypanosomes are inoculated through the skin by the tsetse fly. They are temporarily blocked by the lymphatic glands. The two types, Rhodesian and Gambian, are very similar and differ geographically only. The tsetse fly is very common wherever sleeping sickness exists and wherever the *Glossina palpalis* is absent sleeping sickness never spreads. If a case is brought to a locality where the tsetse fly prevails it soon spreads. It is probable that the transmission by this fly is not of a simple, mechancial type, but that the parasite passes through an extrinsic period of incubation due to the development of the sexual evolution within the insect. This extrinsic period of incubation is about 20 days and the flies remain infective for at least 75 days. Not all flies which drink blood containing the trypanosomes become infected. The proportion is about 1 in 20.

Prevention depends upon the isolation of the sick, protection of both sick and well against flies and the suppression of the flies themselves. The extermination of the fly seems a hopeless task. The larvae remain within the body of the mother until fully developed and are then dropped on moist soil in which they burrow to undergo transformation to the adult stage. The clearing of land in limited locations largely diminishes the number of flies due to the action of the sun causing the earth to become hard and dry. This drying kills the larvae.

The tsetse fly may also be fought by suppressing its food supply. It must obtain the blood of some vertebrate animal every two or three days. By protecting animals and man from their bites much is done toward controlling the disease. Authorities advocate the extermination of big game in the belief that they are the vertebrate reservoir of the parasite.

Deer-Fly Fever (Tularemia): Deer-fly fever or tularemia is an infection due to *Pasteurella tularense* and transmitted by *Crysops,* a biting fly. It is characterized by an enlargement of the lymph glands which drain the bitten area and by a fever of septic type. This disease is also transmitted by animals as described on pp. 160-161.

Fleas. Fleas are laterally flattened, wingless creatures which pass through a similar metamorphosis to that of mosquitoes and flies. The adult female flea deposits her eggs among the hair or fur of the animal host, but unlike the eggs of many ectoparasites, they are not fastened to the hairs and therefore fall freely to the ground.

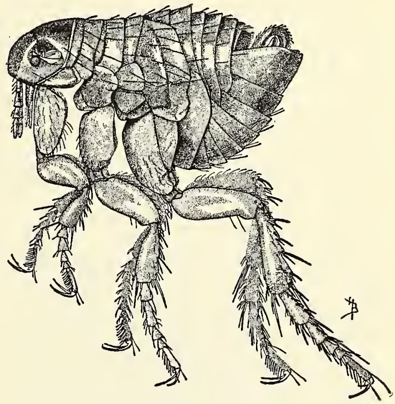

Fig. 91. Human flea (*Pulex irritans*), greatly enlarged.

Courtesy Bureau of Entomology, U. S. Dept. of Agriculture

At the front of the head of the adult flea is a pair of biting jaws. It will be noticed that unlike the mosquito the larval and pupal stages of the flea are not aquatic. In these stages they feed upon refuse usually found around the bed of their animal host. Larvae spin cocoons in which they transform to the pupal stage. It usually takes about 18 days to three weeks for a new generation.

Both the male and female are capable of piercing the skin to obtain blood and thus transmit infection. Fleas as a rule prefer certain hosts and the species which are best known are those who attack several hosts, including man. They are frequently brought into houses by domestic animals and thus become troublesome to man.

Pulex irritans is the human flea and is sometimes called the house flea or common flea. The India rat flea and the common rat flea of

Europe and America are the ones implicated in the spread of bubonic plague. The cat flea, the human flea, the squirrel flea, and doubtless many others may also carry plague. They may carry other infections as for example certain tapeworms in dogs (see p. 49).

Pulicides: Adult fleas succumb to green soap and water. Other substances which will destroy them are: kerosene, petroleum and soft soap, formalin, phenol, bichloride of mercury, DDT, and other insecticides. In flea-infected houses, the larvae living in the cracks of the floor, etc., may be controlled by sprinkling naphthalene (moth flakes) on the floor and closing up the house until the next day. The fleas may be collected for examination by turning loose guinea pigs in a house, collecting the guinea pigs, and thus collecting the fleas which may be examined for plague.

Lice: Blood sucking lice are the only ones implicated in disease. Of these there are three common varieties in man: (1) *Pediculus capitis,* or head louse. (2) *Pediculus vestimenti* or *corporis,* clothes or body louse.[7] (3) *Phthirus pubis,* public or crab louse.

Life History: The insects after emerging from the egg pass through three molts before reaching the adult stage. When young they are about the size of a pin head, but before old age they may become at least $\frac{1}{6}$ inch in length. They have hard smooth coverings which are impenetrable to most chemicals.

The eggs or nits are laid on fibers of clothing or body hair near the base. They prefer to lay eggs on rough material, such as felt, wool, or flannel, hence those who wear flannel underwear are more apt to become infested. These eggs are firmly cemented to the hair and the shells of the eggs remain attached to the hair after the emergence of the embryo. The eggs hatch in from 7 to 10 days. A complete cycle from egg to egg takes about 16 days. The number of eggs laid depends upon the food supply and the temperature at which the female is maintained. Under ordinary natural conditions 300 eggs represent the normal number of which a female is capable of laying; a female louse under ideal conditions may have as many as 4,000 offspring in her lifetime. The average life of a louse is 35 to 40 days. Development of eggs is greatly retarded by cold and therefore persons who remove

[7] *Pediculus capitis* and *Pediculus vestimenti* are grouped together by entomologists under the name *Pediculus humanus.*

FIG. 92. Eggs of the human louse (*Pediculus humanus*) greatly enlarged.

their clothing at night will become less heavily infested than those who wear their underclothing continuously.

Lice feed immediately on their human host after emerging from the egg. A young louse will die in 24 hours if not provided with food, while a well-fed louse can live ten days away from its host. They feed many times during the day but more frequently at night when their host is quiet. When they may become ravenously hungry they feed to excess and even rupture their intestinal canals. Vermin infestation is spread either by contact with infested persons themselves, their clothing, or their personal effects. Lice leave their host when he suffers from a fever or dies. In the former case, the temperature is too high and in the latter case they have no food supply. They may be found on any garment or any article worn by an

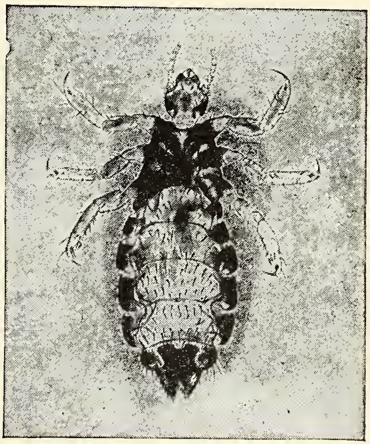

FIG. 93. Human louse (*Pediculus humanus*) enlarged.

Both Courtesy Bureau of Entomology, U. S. Dept. of Agriculture

infested man. In conducting inspections for lousiness, it is important to remember this, and to bear in mind that the body louse may lay its eggs on the hair of the head as well as any other hairy part of the body. The delousing of clothing alone is not sufficient in ridding a person of lice.

Pediculus capitis, or the head louse, is perhaps the commonest variety of louse found. It is found mostly in children, especially in girls on account of their long hair, and in old people. It is fond of the temple region of the skull and the back of the neck. This insect is spread by personal contact or by brushes and hats. If hair is worn short infestation rarely occurs.

Self-treatment for pediculosis is not recommended as many preparations sold by druggists are toxic and may poison a child or an adult as well as a louse. Medical advice should be sought in such cases.

Phthirus pubis, or Crab Louse: This insect looks unlike *Pediculi* and closely resembles a minute crab (see Fig. 21). It is about $\frac{1}{16}$ inch in length. It is usually found in the pubic region (lower abdomen), but may be found over the abdomen and chest, under the arms and down over the thighs. Crab lice have been found in the eybrows. The nit is laid near the base of the hair. *Phthirus* feeds almost continuously, and hence dies rapidly when removed. A female lays about 25 eggs in her lifetime. Eggs hatch in about 7 days. This insect is transmitted mainly by contact in lodging houses, houses of prostitution, bath tubs, and from toilet seats. It has not been known to transmit disease. Treatment is simple and one practical method consists of shaving the hair from infested regions.

Lice Bites and Transmission of Disease: Lice may transmit disease by way of excreta being rubbed into the tiny wounds made by the louse. Persons who are constantly vermin infested are often immunized against irritation of the salivary secretions of the louse. In persons who have never been lousy before the local reaction is intense and may even be indicated by a hemorrhagic spot.

Delousing of Clothing: This is a rather simple process as lice and their embryos are killed by moist heat of 160° F. for 30 minutes. The ordinary steam laundry will suffice as a delousing device. All dry cleaning fluids are effective in destroying lice and nits (embryos). The pressing of garments with streaming steam from a pressing machine in the ordinary tailoring establishment will also kill the parasites. Cloth-

ing stored for two or three weeks will be free of lice as these organisms must have human blood for food. DDT powder will kill lice and nits in a few hours. It was observed in World War II that a single application of DDT powder to a soldier's clothing was sufficient to keep such clothing free of lice for a month.

Rickettsial Diseases: *Rickettsiae*[8] are very small organisms, about one third the size of most bacteria, are difficult to cultivate in the laboratory, and are but imperfectly understood. All pathogenic *Rickettsiae* look alike and are distinguished by the various diseases they produce, the insects or other Arthropoda which carry them, and by certain serological reactions in the laboratory. They cause four diseases, two of which occur in the United States, typhus and Rocky Mountain spotted fever. All rickettsial diseases are carried by Arthropod vectors and have many characteristics in common. They are marked by sudden onset, rash, high fever, and marked prostration. In vertebrates, rickettsial infections localize in the linings of blood vessels, bone marrow, liver, spleen, and lymph nodes.

Typhus Fever: This historic disease has existed for centuries. It followed armies in war time and lodged in jails at all times. Since the disease followed war and imprisonment, it has been said that the history of typhus is the history of human misery and wretchedness. In 1490, typhus fever appeared in the troops of Ferdinand of Spain and was called the "red cloak" because of the rash which developed. In 1501 and in 1516, epidemics of the disease swept over Europe. In 1522, Emperor Charles V of Spain abandoned the siege of Metz because of the great losses from typhus among his troops. During the Thirty Years War (1619-48) the population of Germany was reduced one half, due largely to epidemics of typhus fever. The last great epidemic in war occurred on the Eastern front in World War I where 5 million soldiers and civilians are said to have died of this disease.

In 1577, Rowland Jencks, a Roman Catholic bookbinder, was brought out of jail, where many had died of jail fever, to stand trial before the Chancellor of Oxford University for having expressed certain unorthodox religious views. Because of great public interest in the trial, the court room was crowded. Jencks was found guilty and

[8] Named after Howard Taylor Ricketts (1871–1910) of the University of Chicago. He first described the cause of typhus fever in 1910. He died of typhus, accidently contracted in Mexico, May 3, 1910, at the age of 39, a martyr to science.

condemned to have his ears cut off. Within 12 days of the trial a hundred members of the University had died of jail fever. Ultimately a total of 510 persons died of typhus fever, brought into the court room by the prisoner. From about 1522 to 1750 jail fever was common in England and court sessions were known as "Black Assizes." The last serious epidemic occurred at Old Bailey in 1750.

Tobias Cober first suggested the louse as the vector of typhus in 1706. In 1906, Matthew Hay discovered that the rat flea (*Xenopsylla cheopis*) carried the disease. In 1909, the body louse was proven to be the common vector by Charles Nicolle and his associates, Comte and Conseil.

Typhus fever is caused by the organism, *Rickettsia prowazekii.* There are two types of the disease: (1) the classic form found in Europe and carried by the human louse, (2) the murine type, so called because of its natural reservoir in the rat and tranferred to man through the bite of the rat flea. A mild classic form has been recognized for a long time in this country in the northern states, where it has been known as Brill's disease. In the southern states, bordering on Mexico (where the disease is endemic) it is not uncommon. Both forms are probably identical as an attack of one type gives the individual a lasting protection against the other.

Classic typhus fever is found in cool and temperate climates in Europe, Asia, Africa, North and South America. The most common foci are in Russia, the Balkans, Poland, Galacia, Spain, Italy, Ireland and Mexico.

Typhus is very contagious when in epidemic form and its case fatality rate is very high. In World War II the disease was controlled largely by the use of powdered D.D.T. (dichlordiphenyltrichlorethane) to rid soldiers and civilians of lice. Specific phophylaxis is still in the experimental stage. During World War II, DDT was so effective that vaccines were not developed or refined for general use.

Personal cleanliness is of prime importance in preventing typhus fever carried by lice. Frequent bathing and change of clothing is essential. Using different clothes during the night and the day will inhibit the growth of lice as young forms must feed continuously to live. As stated above clothing may be freed from lice by placing it in streaming steam. Volatile oils, kerosene, and cottonseed oil are popular home remedies to rid one of infestation.

Ticks: These animals are not insects but belong to a related group of Arthropoda. Unlike most insects, they have a long life history, requiring from 2 to 5 years to develop. They hibernate during the winter time and, when active, live entirely on mammalian blood. Their life history is similar to that of the insects. Tick-borne diseases are especially hard to control because of the wide-spread habitat of these vectors which pass disease viruses on from generation to generation through the egg. Ticks are thus the permanent reservoirs of the diseases they carry: Japanese river fever (found only along the river bottoms in the Orient), the relapsing fevers, Rocky Mountain spotted fever, and others.

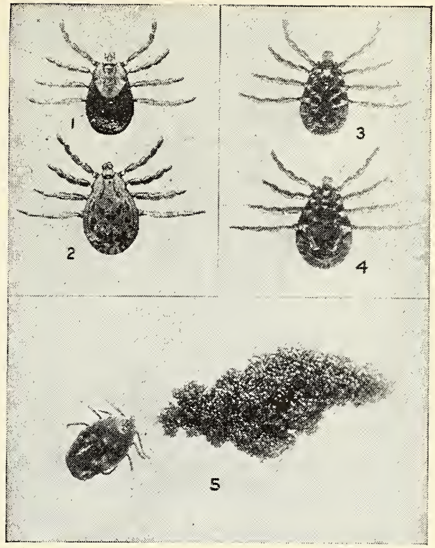

Fig. 94. *Dermacentor venustus.* Rocky Mountain spotted fever tick. 1. Adult female, dorsal view. 2. Adult male, dorsal view. 3. Adult female, ventral view. 4. Adult male, ventral view. 5. Adult female after depositing an egg mass on the ground.

Rocky Mountain Spotted Fever: This disease is caused by a very minute organism, *Dermacentroxenus rickettsi,* and is carried by various ticks of the genus *Dermacentur.* It was originally discovered in the Rocky Mountains but has been reported subsequently in 41 states, South America, the Mediterranean countries, South Africa, Malaya, Japan, and other places. The disease attacks animals and man. It may be mild or severe and often causes death. Recovery from an attack apparently confers a lasting immunity.

Fig. 95. Female tick engorged with blood, ventral view. *Dermacentor variabilis*—American dog tick.

Both Courtesy Bureau of Entomology, U. S. Dept. of Agriculture

The eradication of Rocky Mountain spotted fever has been difficult, and its spread has been causing concern. Protective measures consist in the dipping or spraying of domestic cattle with

oil-arsenic combinations; the clearing and cultivation of land; the killing of infected wild animals and other procedures. Man may protect himself by wearing trousers tucked in high laced boots, tight fitting clothing around the neck and wrists and the application of sulfur or sulfur ointments to the skin, as the tick cannot tolerate this chemical.

In 1925, R. R. Spencer and R. R. Parker of the United States Public Health Service developed a vaccine which has proved effective in the prevention of spotted fever. It was prepared by grinding up highly infected ticks with phenolized salt solution and using the filtered solution for immunization. The vaccine is indicated for those individuals who may be exposed to the disease in areas in which it is prevalent. The U. S. Public Health Service recommends that immunization be repeated yearly just before or early in the tick season, that is in April or May.

Insecticides: Any substance which may be used practically to kill insects is called an insecticide. They may be either liquids, gases, or powders, some of them are extremely dangerous to human life, and safe only in the hands of an expert who understands how to use them. In general they vary considerably in their efficiency, depending perhaps upon the covering of the insect to be destroyed.

Of the gaseous insecticides sulphur dioxide (obtained by burning a sulphur candle) and hydrocyanic acid gas are the most used. The latter should never be used by an amateur.

Sulphur dioxide is one of the most efficient insecticides. It has the disadvantage of forming sulphurous acid when it combines with the moisture in the air, and may cause the disintegration of fabrics. It is also a bleaching agent and will fade many colors. When it is used as an insecticide it should be employed only on dry days, when there is very little moisture in the air. Pyrethrum powder, usually simply called "insect powder," is an efficient and popular insecticide. It is generally applied by means of a small hand bellows, or may be burned in a closed space to kill or stun such insects as mosquitoes and flies. It is made from the flowers of *Pyrethrum roseum* and *Pyrethrum carneum,* hardy perennial flowers (chrysanthemums). It has the advantage of not being poisonous to mammals, and kills insects by stopping their breathing pores. Direct application of the powder is much more efficient than the fumes given off when the powder is burned.

A large number of volatile substances have been used in sprays or atomizers for the purpose of killing insects. Aer-a-sol bombs are popular devices for spreading insecticides in a fine mist and are sold in nearly all drug stores. They contain freon gas, a rapidly expanding gas when released, DDT, and pyrethrum. The combination is particularly effective as the pyrethrum is a rapid insecticide while DDT is long lasting in its action. A list of the volatile substances effective as insecticides is as follows: Quinoline, creosote oil, carbolic acid, kerosene, aniline oil, oil of cloves, oil of citronella, oil of peppermint, oil of pennyroyal, turpentine, and others. Camphor and phenol (camphophenique) when heated give off dense fumes which act similarly to pyrethrum powder when the latter is burned.

Petroleum is a very efficient insecticide, especially if it can be brought into contact with the insect in any of its stages of development. Petroleum or some of its derivatives, kerosene particularly, is the most popular insecticide in general use. It has the advantage of cheapness, and sure destruction.

Carbon bisulphide is an efficient insecticide but a dangerous one, and should only be used by an expert.

DDT, (Dichlor-diphenyl-trichlorethane): This is the outstanding insecticide of modern times. It was first prepared by a German chemist named Zeidler in 1847 who did not test the usefulness of his preparation. A Swiss chemical company, Geigy, Inc., in 1939, found that DDT was effective for mothproofing garments. American research men demonstrated the effectiveness of this substance against body lice, flies, mosquito larvae, and other insects.

During World War II the effectiveness of DDT as an insecticide was tested and verified in less than seven months.[9] A single application of the powder to a man's underclothing would keep him free from lice for a month. It was shown that spraying a wall under certain ideal conditions would make it lethal for flies for a month. Both mosquitoes and their larvae were killed by spraying with DDT.[10]

This substance is not an immediate repellent of insects and its slow

[9] Carey, Frank. "How U. S. Puts DDT to Work on War Front." *Victor News*, v. 17, no. 2, p. 1, February 1945.

[10] Logue, J. B. and O'Connell, H. V. "DDT, Practicality of Use During Invasion," *U. S. Naval Medical Bulletin*, v. 44, p. 877, April 1945.

action tends to make the observer think that no results are being obtained.[11]

A spray in common use is a 5 per cent solution of DDT in kerosene. Sometimes it is mixed with the more rapid repellents mentioned above. Inanimate objects may be sprayed with such solutions with safety. Dogs or other animals should never be sprayed or dipped in kerosene solutions of DDT as the substance in oil may be absorbed by the animal and kill it. DDT is usually nontoxic in dry form and may be used in that form on man and animals.

When mixing DDT with solvents such as kerosene, xylene, or volatile oils and using as a spray the following precautions should be observed: mix the substances out of doors when possible, wear Neoprene gloves when handling, avoid spilling solutions on clothes, change clothes if they become soaked with the solution and wash any skin in contact with soaked clothing, use goggles to prevent eye irritation and a respirator to avoid inhaling fumes from xylene or volatile oils, use greaseless skin lotion to protect the skin of the face, wipe the face frequently with clean tissues and avoid rubbing the spray in the eyes, if not wearing gloves wash hands frequently in soapy water, take a good soapy bath after handling the material, do not spray baby beds, children's toys, high chairs, food, dishes, silverware, or rooms occupied by sick persons, be sure all fires are out when mixing or using the spray as the oils are inflammable.

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13

QUARANTINE, ISOLATION, AND DISINFECTION

Definition: Quarantine derives its name from the Italian words *quaranta giorni* meaning forty days. After the epidemic of plague in 1348 the Venetian Republic appointed three guardians of the public health, and instructed them to quarantine travelers from the Levant isolating them in a detention hospital for forty days.[1] This period of forty days had a biblical significance; Moses and Christ had isolated themselves in the desert for forty days.[2]

The Practice of Maritime Quarantine: The first effective quarantine practiced was that against plague by the Marseilles Harbor in 1383. Since that time it has been extended to include cholera, yellow fever, smallpox, typhus fever, and leprosy or any other communicible disease of an unusual nature prevalent in a port from which a vessel clears. In the United States (and most other countries for that matter) a Bill of Health is required for all ships. This Bill is obtained from the American Consul in the port of embarkation for this country. After arrival in a port here, a careful inspection is made of the ship, passengers, crew and cargo before anyone is allowed to land. During this period of inspection the ship is said to be in quarantine, and flies a yellow flag to denote this fact. The ship remains in quarantine until the officers of the United States Public Health Service are satisfied that no communicable disease is on board. If some serious disease be present among the passengers or crew the ship remains in quarantine for a period equal to the incubation period of that disease, presuming that the case or cases of illness in question have been isolated from those who are well. The cases are usually isolated in a quarantine hospital until they are entirely well and not apt to disseminate pathogenic micro-

[1] Garrison, F. H. History of Medicine, p. 188, W. B. Saunders Co., Philadelphia, 4th ed.

[2] Haggard, Howard W. *Devils, Drugs and Doctors,* New York, Harper & Bros.

organisms. When the vessel is found to be free of disease, the health officer gives the master a free *practique* which the latter presents to the collector of the port, who allows the vessel to dock.

Interstate Quarantine: At times it becomes necessary to practice quarantine between states. Maritime quarantine is usually directed against six diseases, not prevalent in this country, plague, cholera,

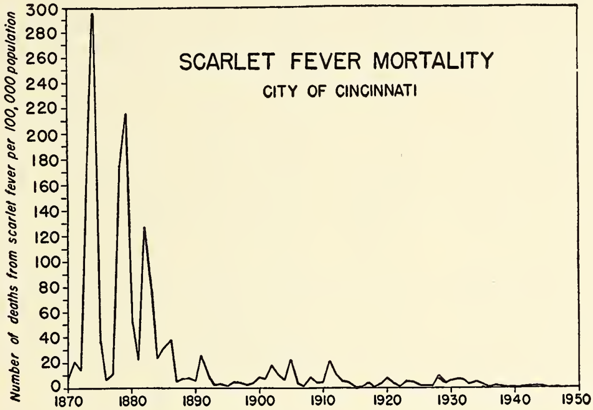

FIG. 96. The only effective measures universally adopted for protection against scarlet fever are isolation and quarantine. Specific prophylaxis has not been popular nor widely practiced, yet the health record for scarlet fever is equal to that of any other communicable disease.
Data Courtesy Board of Health of Cincinnati

yellow fever, typhus fever, smallpox, and leprosy; but interstate quarantine may include a long list of communicable diseases, *e.g.*, infantile paralysis, meningitis, etc. This type of quarantine is only practiced under exceptional circumstances, and great latitude is allowed the quarantine officer. Interstate quarantine comes under the direction of the Division of Domestic Quarantine of the United States Public Health Service, in co-operation with state health officials.

Distinction between Isolation and Quarantine: Technically quarantine refers only to well people who have come in contact with a patient, who, in turn, has a communicable disease. Isolation refers only to the patient ill with a communicable disease. The periods of isolation and quarantine in most communities are given in Table VII.

TABLE VII

Usual Quarantine Regulations

Disease	*Usual Duration*	*Isolation of Patient*	*Incubation Period*	*Quarantine of Exposed Persons (S.C.—Susceptible contacts, I.C.—Immune contacts)*
Anterior Poliomyelitis	3 weeks or more	Until recovery, not less than three weeks	7–14 days	Residing in house—21 days after recovery of patient Residing apart—21 days after last exposure
Chicken pox	1–2 weeks	Recovery—after disappearance of scabs	2–3 weeks	S.C. in house—21 days after recovery of patient I.C. in house—no quarantine
Diphtheria	5–10 days	Recovery, and 2 successive negative nose and throat cultures after 9 days	2–7 days	S.C. negative cultures after exposure ceases I.C. " " " " "
German Measles	1–3 days	Recovery—at least 7 days after appearance of rash	14–16 days	S.C. in house—14 days after release of patient I.C. no quarantine
Measles	Variable	Complete recovery, at least 7 days after appearance of rash	12–14 days	S.C. in house—14 days after release of patient S.C. residing apart—14 days after last contact I.C. no quarantine
Meningococcus Meningitis	Variable	Complete recovery, at least 14 days	2–10 days	Residing apart—14 days after last exposure Residing in house—14 days after complete recovery of patient
Mumps	7–10 days	Recovery (Disappearance of swelling)	12–26 days	I.C. no quarantine S.C. usually daily morning inspection in schools, etc.
Scarlet Fever	Variable	Recovery, at least 14 days (Absence of abnormal discharges)	2–7 days	S.C. Residing in house—7 days after recovery of patient S.C. Residing apart—7 days after last exposure I.C. On release of quarantine or change of address
Smallpox	4–5 weeks	Recovery, disappearance of all crusts	8–16 days	S.C. residing in house—17 days after recovery of patient S.C. residing apart—successful vaccination within 4 days of first exposure no quarantine (at least 7 days are required to determine successful vaccination) I.C. residing apart—none after revaccination
Whooping Cough	6–12 weeks	2–3 weeks after development of characteristic cough	7–16 days	S.C. in house—14 days after release of patient S.C. residing apart—14 days after last exposure I.C. no quarantine

This table illustrates the common practice in most cities of this country, and even in rural districts. There can be very little question about the isolation of those suffering from a contagious disease. The quarantine of healthy individuals often works great hardship on them, however. Most of the diseases listed in Table VII, usually confer a life-long immunity (excepting scarlet fever and probably diphtheria). Therefore all contacts with the patients may be divided into two classes: (1) Those having had the particular disease, and consequently immune; and (2) those not immune. Artificial immunity of a high degree may be obtained in at least three: smallpox, typhoid fever, and diphtheria. All immune contacts need not be quarantined if they will not live in the same house with the patient. Susceptible people are usually required to change their residence in the case of the more serious diseases, and remain quarantined for the period provided by local laws.

Disinfectants: Disinfectants vary greatly in their mode of action and their efficiency. Some promptly kill microbes while others merely inhibit their growth and reproduction. Rosenau makes these distinctions.[3]

> Disinfection means *the destruction of the agents causing infection* and deals only with destroying the vitality of the minute forms of life which cause disease. It does not mean the destruction of all the lower forms of animal and vegetable life that may be in or upon an object—this is called sterilization . . . Antiseptic substances *prevent decomposition and decay* . . . without destroying the organisms which cause the process. Asepsis means *freedom from or absence of living pathogenic microorganisms.* A germicide is a *substance or agent which destroys germs.* Germicides and disinfectants are interchangeable terms, as both are used to indicate the destruction of microorganisms. A deodorant is a substance which has the power to destroy or to neutralize unpleasant odors. Fumigation consists in liberating fumes or gases with the object of destroying germs, vermin, insects, rats, mice, and other small animals acting as carriers of infection.

Physical Disinfectants: Sunlight is extremely efficient as a disinfectant when allowed to come into contact with bacteria. Neither bacteria nor spores are able to withstand its continued action. The tropical sun is the most active. Sunshine on mountain tops is usually more active than in lower regions. Many things filter out the active shorter wave-length rays in sunshine such as window glass, smoke,

[3] Rosenau, M. J. *Preventive Medicine and Hygiene.*

fog and dust. Ultra-violet rays, those of shorter wave lengths usually between 2,900 to 2,200 Angström units (one Angström unit = $\frac{1}{100000000}$ cm.), are found in radiations from the sun. They are efficient germicides. Various substances, however, filter out the ultra-violet light, *e.g.*, air itself will absorb it.

Bacteria vary greatly in their resistance to ultra-violet light, *e.g.*, the tubercle bacillus is not quickly killed by it but may survive for some time. The structure of different bacteria seems to be an important factor. The tubercle bacillus is known to possess a waxy capsule and it is believed that this capsule filters out some of the ultra-violet light. Spores are more resistant to it than bacteria. The ultra-violet light may be produced artificially.

One cannot get ultra-violet light from the sun into his room without the use of special glass. Quartz will permit the ultra-violet rays to pass through but is too expensive for ordinary use. Some commercial glass has been made which is efficient for a time but which deteriorates eventually. This also is very expensive.

The best way to use the sunshine for its ultra-violet light is to apply it directly to the patient, as is done by Dr. Rolier at his group of sanatoria in Leysin, Switzerland. Here patients with so-called surgical tuberculosis have been very successfully treated by exposing them on open porches to the direct action of the sun. One is struck with the nature of reaction to this light, however, on the part of the patient. Most of the latter burn to a deep mahogany color, and become very resistant to the cold. There are effects produced by wind, diet, and mode of living at the sanatoria at Leysin because patients in this country when treated in a similar manner do not usually show the same reactions.

Ultra-violet light has been used to purify drinking water and disinfect swimming pools.

Fire has been used for many centuries to kill microorganisms. In the Bible fire is rightly considered the great purifier. If waste substances can be burned completely the infective agents are disposed of for all time.

Dry heat is not as satisfactory a disinfectant as boiling which kills all microorganisms except spore-bearing ones. Steam sterilization, best exemplified in the Arnold sterilizer, will kill all the nonspore-bearing organisms.

TABLE VIII

Disinfectants in Common Use

Physical	*Chemical*		
Sunlight Ultra-violet rays	Gaseous at ordinary temperatures	Liquid at ordinary temperatures	Solid at ordinary temperatures
X-rays	Formaldehyde	Coal tar derivatives	Coal tar derivatives
Electricity (by thermol and electrolytic action)	Sulphur dioxide	Creosote	Asaprol
Pressure (over 6,000 atmospheres)	Hydrocyanic acid gas	Carbolic acid (crude)	Orthocresol
Fire	Chlorine	Phenol (chief constituent of carbolic acid)	Paracresol
Dry heat over 150° C.	Ozone	Metacresol	Naphthols
Boiling water	Glycol vapor	Lysol	Naphthalene
Steam (streaming)	Triethylene glycol	Aseptol	Salts must be in solution to be effective
Steam under pressure		Sanatol (proprietary)	Mercuric chloride
		Oxidizing agents	Silver nitrate
		Hydrogen peroxide	Silver cyanide
		Elements	Zinc chloride
		Bromine	Sodium thiosulphate
		Formaline	Copper sulphate
		Acids	(Oxidizing agents)
		Hydrochloric	Potassium permanganate
		Hydrobromic	Calcium hypochlorite
		Sulphuric	Sodium hypochlorite
		Nitric	Sodium sulphite
		Boric	Elements
		Acetic	Iodine
		Citric	Mercury
		Formic	Dyes
		Salicylic	Gentian violet
		Tartaric	Malachite green
		Alcohols	Acriflavine
		Ether	Soaps
		Chloroform	
		Xylene	
		Benzene	

Steam under about 20 pounds per square inch pressure in an autoclave for about 30 minutes will kill all bacteria and spores. It is extensively used in hospital asepsis, and in bacteriological laboratories.

Gaseous Disinfection: Sulphur dioxide, formaldehyde, and hydrocyanic acid gas are the common gaseous disinfectants. Of these formaldehyde is the one most commonly used and has the power of killing microorganisms and their spores if it can get to them. Unfortunately it cannot be depended upon for more than a surface disinfection. It is a better germicide than sulphur dioxide or hydrocyanic acid gas. The latter two are efficient insecticides but cannot be depended upon for disinfection.

Chlorine has considerable germicidal property when in solution. but as a dry gas is extremely uncertain. Very large quantities are necessary when so used.

Nascent oxygen and ozone are very active germicidal substances but are rather expensive and for the most part impractical.

Solid and Liquid Disinfectants: Solids are most generally used in liquid form. Mercuric chloride in solution (bichloride of mercury, corrosive sublimate) is one of the most efficient germicides. Unfortunately it is not any too stable in water solutions and is usually mixed with some other substance (*e.g.,* ammonium chloride) in antiseptic tablets to facilitate solution and render the solution more stable. It is used in solutions of varying strengths and in relatively weak solutions has a marked germicidal action. In the proportion of 1 part to 500 mercuric chloride will kill bacteria and spores. In this strength it is irritating to and destroys most human tissues. It has a number of disadvantages: (1) it will corrode all metals and will deposit mercury on them; consequently it cannot be used for sterilizing instruments. With some metals it readily forms an amalgam and changes the nature of the metal. It seems to do some harm to all metals with which it comes in contact. (2) It is extremely poisonous, precipitating the proteins of human tissue and causing an extensive destruction of the gastro-intestinal tract when taken internally. It is a very dangerous chemical to have around homes. (3) When combined with albuminous matter it is rendered worthless, consequently it is neutralized in most cases when it is brought into an infected wound. It is not useful in disinfecting urine and feces because of the albuminous matter therein.

Other solids include iodine (tincture 3.5 per cent), mercurochrome

and merthiolate 2 per cent solution in alcohol. Widely used also are potassium permanganate, sodium hypochlorite, and chlorinated lime. Soap is only mildly antiseptic but has great value as a cleansing agent. On the other hand tincture of green soap, which is liquid soap in 70 per cent alcohol, is an excellent disinfectant.

Some of the liquid disinfectants are carbolic acid 2.5-5%, formalin 10-40%, cresol, hydrogen peroxide, and alcohol 50-70%.

An attractive color and pleasant odor add nothing to the value of a disinfectant. Most such preparations are useless.

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14

WASTE DISPOSAL

The disposal of waste is one of the most important problems arising out of the changes in habits and environment of civilized man. The matter has passed from the stage of being merely a nuisance and incidental worry; it now receives the attention of highly trained specialists in the field of sanitation and health. The science of santitary engineering has progressed from the mere digging of a hole in the ground to the construction in many instances of a vast and expansive plant with several parts or systems, all with the single function of waste disposal.

Satisfactory health standards are dependent upon efficient waste disposal. This is due to the fact that a number of serious diseases may be and often are transmitted by discharges from the gastro-intestinal tract; the most important of these are typhoid, paratyphoid, cholera, dysentery, hookworm, tapeworm, and tetanus. The sanitary problem has to do chiefly with the purification and disposal of waste, the prevention of secondary carriers coming in contact with human wastes, and the guarding of food and water.

Sewage Disposal: Sewage is the human excreta and other wastes coming from dwellings, manufacturing plants, or places of business. In the community it may be defined as that material which passes through the sewerage system.

Progress in the disposal of sewage has been slow. Man acquired civilization at a much more rapid rate than he learned efficiency in the disposal of sewage. In the beginning his efforts to meet the problem were comparable to that of the dumb animals. The realization of the necessity of establishing and maintaining some method of disposal of sewage as a means to promote health and decency accompanied the grouping of men into dwellings and communities and came only after bitter experience with disease. The contamination of the water supply and the creation of a nuisance were the first problems to

be considered by the early pioneers in this field; secondary carriers were unheard of and therefore caused no concern.

Earliest methods of sewage disposal were developed by those living in isolated dwellings. One procedure was the use of a narrow trench; when the trench was nearly filled with waste material it was covered with dirt. This was an improvement over the promiscuous deposition of human waste about human habitations, or even the common practice of using an open frame structure near the house. These methods provided breeding places for disease organisms and a source of pollution for flies and other secondary carriers. In many countries it was a common practice to use a large tub to collect human wastes which were later used as fertilizer in the fields. This method is still used in certain parts of the world.

Rural Sewage Disposal: Sewage disposal on the farm offers problems which are unknown in the large community. Without a sewerage system the farmer must create his own disposal system. With this fact in mind it is easily understandable why the death rate from typhoid is much higher in the country than in the city.

It is necessary in the country that the sewage be disposed of in such a manner that there is no danger of polluting the water or ice supply; it must not be exposed to secondary carriers; and the excreta must not come into contact with vegetables or fruits, and must be placed where the livestock do not come in contact with it.

There are two general methods of disposal: (1) dry and (2) wet. The wet disposal is preferable but is impossible without the presence of a pressure water system. The several methods of dry disposal are:

Dry Sewage Disposal: The pit privy: In this case the superstructure is moveable and is placed over an open pit. The excreta falls into the pit and after the pit has been partially filled the superstructure is moved away to a new pit and the remainder of the old pit is filled with earth. In this type of disposal it is necessary that the pit be screened from insects and animals. It is also very essential that the pit be placed so that there is no possibility of the excreta seeping through the earth and contaminating the water supply, vegetables, or fruit.

The receptacle privy: In this type the structure is also entirely screened against insects and animals. A container for the excreta that is capable of being easily moved and emptied is placed under the superstructure and the bottom of the container is covered with dry saw-

dust to a slight depth. The seat on the superstructure should have a self-closing spring lid which will close that entrance to all insects. The container should be emptied at least once a week.

The chemical closet: The chemical closet has the advantage of being practically odorless and consequently may be used inside of the dwelling. There is an iron tank placed beneath the toilet seat. This tank contains a very strong solution of caustic soda into which the excreta falls. The excreta is disinfected and partially dissolved. The tank can be opened and the contents removed at suitable intervals. This is the only method of odorless dry disposal and is used generally. There is usually a pipe from the tank to the outside air to carry off any odor.

Wet Sewage Disposal: The cesspool: The cesspool is perhaps the most simple system of wet disposal and is the easiest to construct. The cesspool closely resembles a shallow well and the walls are made up of fairly large rocks that fit loosely enough to allow the liquid effluent to pass into the surrounding soil and find its way to the nearest stream. In the passage from cesspool to stream it may be to a large extent purified. The solids accumulate in the bottom of the cesspool and are greatly reduced in volume through the septic action of bacteria. The action takes place in the absence of oxygen under the surface of the effluent and is anaërobic in nature. The solid matter should be removed periodically. The cesspool has many disadvantages and is not recommended. It is being rapidly replaced by the septic tank.

The Septic Tank: This process is anaërobic. The tank is permanent and is usually constructed of cement. The sewage is brought in on one side of the tank through a closed watertight line of tile and the solids are allowed to settle to the bottom of the tank. There they undergo anaërobic septic action. The reduction of the solid volume in the decomposition process is explained by the fact that there is considerable gas and liquids formed from the destruction of solids. This solid material or sludge should be removed at regular intervals depending upon the rate of accumulation. In well constructed tanks, means such as baffles are provided to slow and distribute the flow of sewage through the tank. The effluent is mostly liquid but it also contains some solid matter. The septic action itself only partially purifies the sewage and therefore the effluent must receive further treatment. The too common practice of running the effluent directly into an open ditch or body of water usually creates not only a nuisance but a health

hazard as well. To complete the purification process a disposal field of some sort is necessary. A watertight lead carries the effluent from

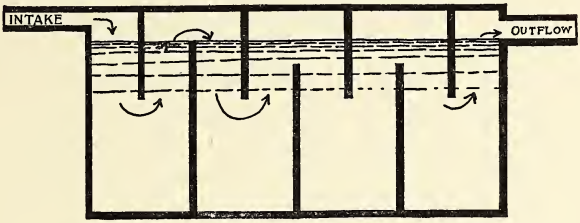

Fig. 97. Diagram of the septic tank.

the septic tank to the distributing tile with separated joints where the effluent is allowed to escape into the surrounding soil. Here there is further destruction of pathogenic organisms but in this instance by aërobic bacterial action in the soil. A number of factors such as the amount of effluent, the elevation of the ground and the nature of the soil will determine the location and plan of the disposal field. Commonly the disposal tile are laid in branching and parallel lines. Sandy and porous soil may need little or no preparation. Usually, however, the soil is more or less impervious and in order to secure proper filtration it is necessary to construct a filter bed of sand and gravel in which to lay the tile. After proper filtration the effluent may be disposed of in any convenient method with safety. The installation of a septic tank system requires considerable knowledge of sanitation and should never be done except under the direction of one trained in that field. Many of the septic tanks in use today have limited or no value due to improper construction. To the owner they give a false sense of protection and to the public health sanitarian one of his greatest problems.

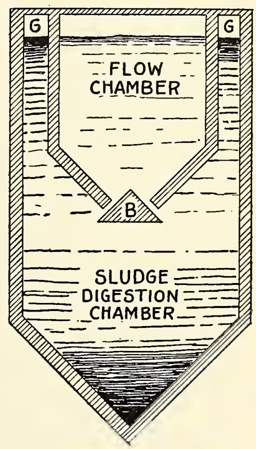

Fig. 98. Cross-section of Imhoff tank (see text). Gases accumulate at G. Baffle plates are located at B.

The Imhoff tank: In the Imhoff tank there are several compart-

ments. There is a flow chamber into which the sewage is admitted. Baffle boards quiet the flow and allow the solid matter to settle down a sloping partition and drop out of the flow chamber into the sludge digestion chamber where anaërobic septic action takes place. The entrance into the digestion chamber is by means of a slot in one side of the bottom of the flow chamber. The gas that is given off during the digestion process arises in another chamber from the flow chamber. The effluent passes out the other side of the flow chamber and is disposed of as in the septic tank process. The digested solids, or sludge as it is called, are removed from the digestion chamber at intervals. The aforementional baffles and a screen over the exit to the flow chamber are inserted to prevent the solids from being carried away by the effluent.

Community Disposal: Sewage disposal in the community embodies many of the problems encountered in rural disposal and more in addition. The volume of sewage constitutes a special problem.

There are three main types of methods used for the disposal of community sewage:

Direct Disposal: In this method, which is by discharging the sewage into a body of water, it is very essential that the volume of the river, lake, or ocean into which the sewage is discharged be sufficient to efficiently purify the sewage. A stream is capable of purifying one-fiftieth of its volume in raw sewage. With the population becoming more centralized it is unwise to attempt the direct disposal of sewage into inland streams which are used as the source of drinking water by other communities.

Chemical Purification: In chemical purification the sewage is purified through the disinfecting action of chemicals. There are two chemical methods used at present:

Precipitation method: In this method the sludge, or solids, are precipitated out of solution by the addition of lime and alum.

Miles process: The disinfection by use of the Miles process is caused by sulphurous acid coming into contact with the sewage. Sulphur is burned and the sulphur dioxide gas produced is bubbled through the sewage. This gas unites chemically with the hydrogen in the liquid content producing sulphurous acid.

Bacteriological Purification: Both anaërobic and aërobic methods are used in the bacteriological purification of sewage; aërobic methods

make use of the addition of oxygen to the sewage as the bacteria in the sewage are breaking down the sewage composition. Nitrates are finally produced and are useful as fertilizers. Carbon dioxide is also released. The sludge remaining has somewhat the consistency of humus soil.

Intermittent Sand Filtration: There are beds of sand which are four to five feet in depth and about an acre in area. Open lines of tile are laid beneath the sand beds. The sewage is allowed to flow on to the sand beds until it has reached a depth of four or five inches. After this the bed is allowed to stand until it has dried. Several hours later another dose of sewage is allowed to flow over the bed. The effluent from the sewage runs through the sand and is carried away by the tile lines. This effluent is very nearly purified in the filtration process and is discharged into some nearby stream. The sludge, or solids, in the sewage remains on top of the bed.

The marked efficiency of this method lies in the fact that the top three or four inches of the sand bed are covered with a gelatinous layer over the individual sand grains. This layer is composed of oxidizing bacteria. The gelatinous covering forms a tighter and more efficient filter the more it is used. The oxygen-breathing bacteria need time to breathe and this is the reason for the delay before repeating the sewage dose.

Sprinkling Filters: This process requires the construction of a bed five or six feet deep containing large (two inch) pieces of broken stone, coal, or coke. This filter bed is built over a drained concrete platform. The sewage is sprayed through a nozzel on to the filter and the oxygen is derived from the air as the sewage runs through the filter.

Activated Sludge: The sewage is placed in a deep tank and air is bubbled through the sewage by means of holes in a false bottom. The oxygen of the air bubbles activate the sludge and nitrates form rapidly.

Sewage Farming: This practice is quite common in Europe and has been tried in California. However, it has not proved practical in the United States. The sewage is allowed to flow over farm lands where the soil is largely sand or gravel. The solids remain on the surface while the effluent soaks down through the ground to the stream draining that locality. The effluent is practically pure by the time it reaches the stream. The solids are usually plowed under into the soil.

Anaërobic methods bring about the decomposition, sludge digestion,

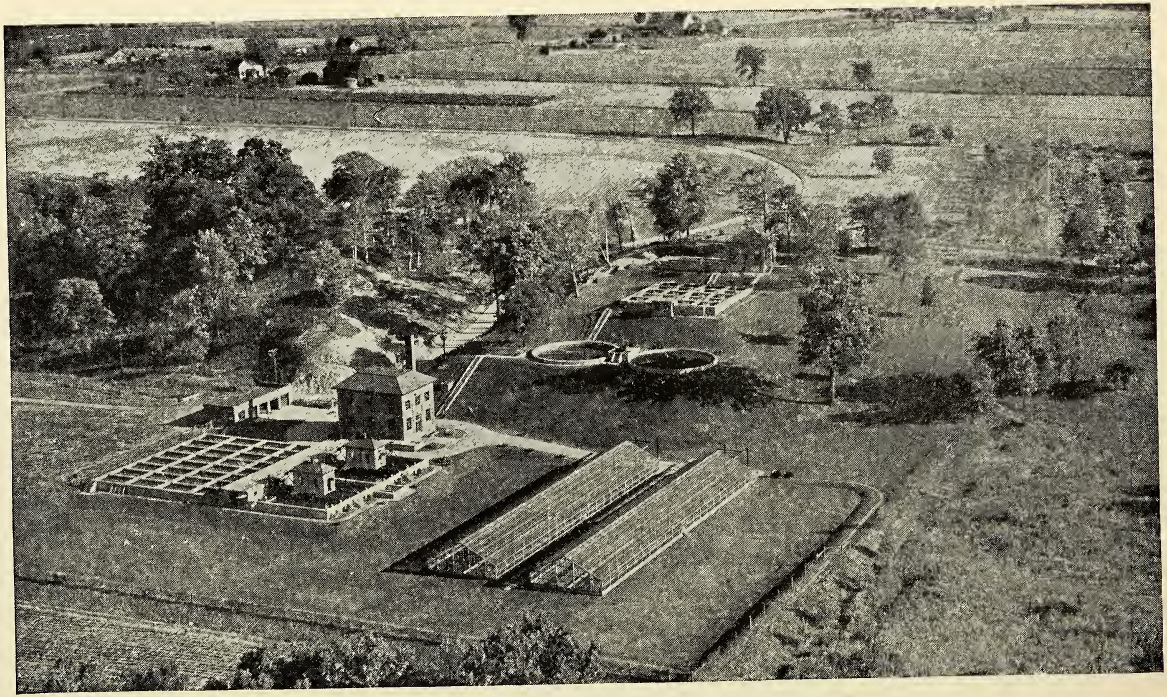

Fig. 99. Sewage disposal plant at Elyria, Ohio.

Photo by Aerial Surveys, Inc., Cleveland, Ohio

in the absence of oxygen. The sewage is in some form of tank and free oxygen-breathing bacteria soon use all the available oxygen and die for lack of that element. There then remain only the anaërobic bacteria; those which are capable of extracting their oxygen from the organic matter undergoing decomposition. This septic action releases three different gases from the sewage; all from the decomposition of proteins. They are hydrogen sulphide, ammonia, and nitrogen. In addition to these gases the decomposition of carbohydrates releases methane and carbon dioxide. Thus the solid is greatly reduced in volume. Certain of the methods have already been described in the treatment of the rural problem and need not be repeated.

Summary: Of the processes here outlined there are several which stand out as the most efficient from the standpoint of purification of the sewage. The aërobic sewage farm method is the most efficient of all. Next comes the intermittent sand filtration method closely followed by the activated sludge process. It thus appears that certain of the aërobic methods are the most efficient.

In modern community sewage disposal plants there is often a combination of several methods used. The disposal plant of the city of Elyria, Ohio, is a good example. Here the sewage runs from the main sewage pipe through bar screens which remove all rubbish or twigs of any size. Next, the sewage passes over grit chambers into which all gravel, cinders, and such things are allowed to settle. From here the sewage is subjected to primary sedimentation in Imhoff tanks. The effluent is pumped away to secondary sedimentation tanks and after passing through these tanks the effluent is aërated by the activated sludge process and then after further sedimentation is discharged into a nearby river. Any solids settled out in the secondary settling tanks are pumped back into the Imhoff tanks. The solids are allowed to

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Explanation of Figure 99. The small house in the background is the screen building next to which are the grit chambers. A small flight of steps leads to the primary settling tanks (Imhoff tanks). A longer flight of steps leads to the two large round sludge digestion tanks. The longest flight of steps leads to the main power house, behind the left foreground. In the left foreground are the aëration tanks, next to which are the two settling tanks (surmounted by two small buildings). The two large glass covered buildings in the center of the foreground contain the sludge drying beds. The progress of the sewage is from the grit chambers to the Imhoff tanks, to the sludge digestion tanks, to the aëration tanks, to settling tanks, and finally to sludge drying beds. Water is extracted from the sewage from time to time during its progress through the plant.

digest for a time in the digestion compartments of the Imhoff tanks and are then pumped from the bottom into two large septic tanks. Here the sludge remains for several weeks and is drawn from the bottom down to covered drying beds of sand where all superfluous moisture is removed. The dried sludge is then used for fertilizer.

Refuse Disposal: In addition to sewage, there are other waste substances which must be disposed of to promote cleanliness, esthetic enjoyment of the home, and health in general. These wastes include garbage, ashes, manure, dead animals, offal, and rubbish (other wastes). Their disposal presents one of the most persistant and perplexing problems in the field of public health. There are many reasons for this. In addition to the health considerations there is the esthetic sense which has been so highly developed in this country. For example, offense to the sense of smell is probably the most common cause of complaint to the health department.

The practice in the disposal of refuse varies greatly and there are a number of methods used. This means that there is no satisfactory procedure that can be followed in all localities.

The individual householder who has no access to a community service may dispose of his refuse in a number of ways. The ashes may be put on a private roadway, used to fill in low ground or, together with rubbish, be hauled away to an approved dumping ground. Combustible material may be burned. Some dispose of garbage by burning it. Others feed it to animals, especially hogs. A gardener often buries his garbage; it makes good fertilizer but there is a danger of attracting rats and other animals unless it is well covered with dirt. A comparatively new method uses the house drain and sewer system in the disposal of garbage. This is possible where there is running water in the home. The disposal unit is installed under the kitchen sink and connecting it to the drain below. The food wastes are first ground to a pulp by the electrically run machine and then flushed into the drain. This operation is successful and finds favor with the housewife.

Although the particular procedure followed may be different, the same sanitary principles should be used in the disposal of all refuse matter. Whether or not this is satisfactory will depend upon the intelligence, community conscience, and social sense of responsibility.

In small villages there is frequently found community health problems altogether out of proportion to the size of the population. This

is because by living close together the people are exposed to all the dangers of close association but the community is not financially able to provide the protective measures possible in larger towns and cities. The practices followed in refuse disposal include those of the individual home owner, discussed above, as well as certain community measures. In many villages the garbage is removed by one or more private collectors who are engaged by individual citizens. This method is not satisfactory. Whatever the practice, it should be uniform for everyone and cover the entire village or city. It is more satisfactory to have collection and disposal made by the municipality rather than by contract to some individual. This applies not only to the collection of garbage but ashes and rubbish as well. As everyone in the community benefits from a satisfactory waste disposal everyone should help pay the expenses. This means that the expense should be spread upon the tax roll.

Refuse disposal methods have had their greatest development in large cities. Here as in smaller communities the practice varies.

Separate containers should be used for the collection of garbage, ashes, and rubbish. At least the garbage should be separated from other refuse. The multiple can system permits a more satisfactory disposal. A galvanized iron can with a capacity of six to ten gallons is recommended. It should have a tightly fitting cover. This confines the odor, prevents flies from laying their eggs in the garbage, removes an important food supply for rats and prevents dogs and other animals from spreading garbage over the lawn and street. There are advantages in having the cans supplied by the municipality.

The method of placing the cans is usually covered by a local ordinance. They should be set on a well-drained platform. Draining and wrapping the garbage, when the method of disposal will permit, will prolong the life of the can and facilitate the collection.

It is important that the garbage be collected regularly; twice a week from the residential and daily from the business districts. This prevents the breeding of insects. The garbage may be carried away in the can and a clean container provided at each collection. More commonly it is dumped into a truck. In the latter case the responsibility for the proper care of the can falls on the householder. The cans should be dried and cleaned each time their contents are removed.

Chemical disinfection should not be practiced when the garbage is being fed to hogs.

The method of choice for final disposition of refuse will vary somewhat according to such factors as size and wealth of the community, geographical location, and others. Dumping garbage at sea or into a river after grinding has been used by some cities. Unfortunately winds and tides bring the waste back to land creating a nuisance and danger to residents along the shore and swimmers on the bathing beaches. Another objection is the expense of the operation.

A common practice is dumping garbage, and other wastes, on open and low land in some isolated spot. This is done because it is convenient and inexpensive. Low areas can thus be filled and made useful. This method may be satisfactory with close supervision. Such dumps, however, are generally unsightly, foul smelling and a breeding place for flies and rats. Fires and smoke are usually other objectionable features of such places.

The burial of garbage has been practiced widely. In theory it is a good method but in practice it is often unsatisfactory. It is satisfactory only when the garbage is well covered with soil and the whole operation has intelligent supervision. The garbage may be placed in furrows and plowed under when the land is to be cultivated; it then serves as a fertilizer. This method is unsatisfactory because there usually is some garbage left uncovered and none of it is buried deep enough to protect it from vermin, and even domestic animals. When waste land is available garbage and other wastes may be buried in trenches dug five or more feet deep and then well-covered with dirt. The layer of dirt over the garbage must be sufficient to prevent animals from digging it out (18 inches or more). The Sanitary Fill is a modification of this method. A tract of useless low land is found in or near the city. After careful study and planning by city engineers the area is reclaimed by filling it with garbage, ashes and rubbish. The operation consists of dumping the mixed refuse into a ditch which has been dug along one side of the area. The refuse is then compacted by mechanical equipment. The final step in the operation is to cover the refuse and fill the ditch promptly each day to a height of two feet or more above its original level with dirt taken from a second ditch, two or three feet away and parallel to the first one. In this manner one ditch after another is filled until the level of the whole area is finally

raised and reclaimed for some useful purpose. This scientific procedure is in marked contrast to that found in the ordinary town dump referred to above. The Sanitary Fill is to be recommended.

One of the most satisfractory methods for disposal of garbage and other combustible wastes is incineration. When this means is used other ways must be provided for the incombustible refuse. Incineration is expensive but seems to be increasing in favor because of the difficulties experienced with other methods. Modern plants also have improvements in working conditions, economy in operation and control of smoke and objectionable odors. Incinerators are often located centrally and the short haul, in contrast with some other methods, is also in its favor. Burning the combustible material with garbage makes for economy in refuse disposal. Household garbage should be dried and wrapped in paper.

The reduction of garbage is a complicated process by which fats are extracted. Solvents such as naphtha and gasoline may or may not be used. Glycerine and alcohol may also be recovered from the garbage. The tankage, or dried residue, is used as fertilizer. The reduction process is attended by many problems; it is expensive, the odors are very offensive, and the disposal of wastes difficult. For these, and perhaps other reasons, reduction plants are not common. They serve a very useful purpose however for the disposal of dead animals.

Hog feeding is used more than any other method for the disposal of garbage. It is practiced by the individual householder and communities from the smallest to the largest. This is not because it is the method of choice. It is popular because it is adaptable to communities of all sizes, requires less financial investment, and offers greater profit in comparison with some other methods. Also, it demands less technical training and experience than some other methods mentioned above. In spite of its popularity, it should be clearly understood that hog feeding has very definite disadvantages. The handling of garbage alone is a messy business but the combination of garbage and swine is almost intolerable. Unless carefully supervised and closely controlled, hog farms may, and frequently do become not only a nuisance but a health menace to the neighborhood. The vermin, flies, vultures, stray dogs and disagreeable odors generally associated with such farms are a disgrace to any self-respecting neighborhood.

The feeding of garbage to hogs has resulted in an extraordinary

amount of trichinosis among the rats infesting such places. The rats become infected from the uncooked portion of the garbage, the swine eat the rats, as well as uncooked meat, and thus the circle is complete, with or without the rat, from hog back to hog again. The dangers of other diseases of hogs and rats are also increased. (See Chapter 10.) When garbage is fed to hogs provision must still be made for disposal of ashes, rubbish, as well as a considerable portion of the garbage itself which is inedible.

The hog farm should be operated by the municipality rather than by private contractor. The reasons for this are the same as those given for other methods of disposal discussed above. The farm should be located in some isolated spot, not too far from the city, and at least one quarter mile from the nearest residence or place of business. Hog raising is an intricate business and requires good buildings and equipment. Under efficient management it can be made a successful operation and nuisances and dangers minimized but it requires eternal vigilance. Periodic inspection by the public health authorities is highly desirable.

Aside from the dangers referred to above the pork of hogs raised on garbage is as good as grain-fed pork. The hog is a very intelligent animal and carefully selects the edible and rejects the inedible. Cooking, or sterilization of the garbage by heating, reduces its nutritive value. The hog manure and uneaten garbage may be buried and used as fertilizer.

Other methods have been tried in the disposal of garbage. Preference has been made to grinding the garbage as it leaves the kitchen sink. This principle has been extended by establishing grinding stations at strategic places in the city where garbage is collected; also by grinding the garbage at the sewage disposal plant and disposing of it there. The fermentation method depends upon the digestion of the garbage by bacteria after being deposited in partially closed bins made of concrete.

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15

THE ACCIDENT PROBLEM

Place of Accidents in the Health Picture: That accidental disability and death is a major health problem can be realized from mortality statistics shown in Table IX. The National Safety Council, Chicago, a voluntary health organization, publishes extensive data on the accident problem. Its yearly handbook, *Accident Facts,* is the standard source from which much of the material on this question is usually obtained.

Communicable diseases have shown a marked decline in mortality, as a rule, since the beginning of the twentieth century but accidental deaths have remained remarkably constant. Perhaps some advance has been made in accident prevention for machinery, chemicals, and other inanimate causes of disease and death have been more universally applied to general living conditions than ever before. It is possible that an increase in the accident rate was to be expected and that some gain has been made in keeping the accident rate at a nearly constant level.

Types of Accidents: In one classification, motor vehicles cause the largest percentage of accidents followed by falls, burns, drownings, railroad accidents, firearms, poisonous gases, and other poisons. Of the main classes of accidents the order is: home accidents, motor vehicle accidents, public accidents (not motor vehicle), occupational accidents, and occupational and motor vehicle both (chauffers, truck drivers, laborers, etc.). Formerly occupational accidents stood first but by reason of careful study and remedial action, industry has brought about great improvement in incidence and severity of occupational injury.

Causes of Accidents: The exact cause of an accident is sometimes difficult to determine. It often depends upon the degree of intelligence of the person suffering or causing the accident, his habits of drinking or sobriety, his home conditions, emotional status, physical factors in his environment, and many others.

The greatest advances in accident prevention have occurred in in-

TABLE IX

LEADING CAUSES OF DEATH IN THE UNITED STATES
1946

Rates per 100,000 population
(Exclusive of still births and deaths in the armed forces overseas.)

1. Diseases of the heart (all forms)	306.8
2. Cancer and other malignant tumors	130.1
3. Intracranial diseases of vascular origin	89.8
4. Accidental deaths	70.1
5. Nephritis	58.4
6. Pneumonia and influenza (all forms)	44.6
7. Diseases peculiar to the first year of life (premature birth, etc.)	44.1
8. Tuberculosis (all forms)	36.4
9. Diabetes mellitus	24.8
10. Senility, undefined and unknown causes	19.7
11. Arteriosclerosis and high blood pressure	19.1
12. Congenital malformations	12.7
13. Suicide	11.5
14. Cirrhosis of the liver	9.6
15. Syphilis	9.3

SOURCE: Official data, Federal Security Agency, U. S. Public Health Service, National Office of Vital Statistics.

dustry. The various state industrial commissions have co-operated with industries and advised plant owners concerning safe methods of operation. Compulsory accident insurance in industry is practically universal in the United States and those industries having good experience pay low premium rates while those which are dangerous or unsafe are required to pay high rates. If a plant has to pay high premiums for accident insurance, these premiums add to the overhead cost of manufactured articles and when it competes with others paying low premium rates it is apt to lose out in modern business competition. The workingman's compensation principle has thus added the high cost of accidents to the cost of manufactured articles instead of placing it on the injured workman or the community.

In industry, it is a noteworthy fact that accidents caused by purely physical factors such as unguarded machinery, improper illumination, and ventilation, have steadily declined. That such accidents have not entirely disappeared showed that other factors are contributory causes.

Everyone recognizes that negligence is the primary cause of injury. In fact negligence on the part of the person injured or someone else is responsible for nearly all accidents. In automobile accidents human failure is a cause of many more injuries than mechanical failure of the automobile itself.

Among the many factors in accident causation heavy traffic, crowded conditions of cities, unsafe and badly designed highways, obstructions to vision, excessive noise, improper illumination of streets are among the main preventable and contributory causes. Inebriety, peculiar psychological attitudes, carelessness, indifference, inability to concentrate attention on a given task or activity, physical defects of the individual, especially those concerned with seeing and hearing, ineptness, and many other deficiencies in the individual are definite causes of accidents.

Home Accidents: Man spends much of his time in and around his home and the largest number of accidents are to be found in this location. They usually occur in the yard, kitchen, or on the stairways. Contrary to popular belief, very few accidents occur in bathrooms. Falls are the most common type of accident in the home. Such falls are usually caused by tripping over rugs, falling down steps, or slipping on polished hardwood floors.

Burns in the kitchen are common and serious home accidents. These occur frequently in children playing about the stove. Striking against articles, being struck by falling objects, cuts from knives, injury in carrying objects, and poisoning occur in the order mentioned. Education concerning home accidents should be given more attention in the curricula of schools and other methods used to make people more conscious of the prevalence and seriousness of accidents in the home.

Motor Vehicle Accidents: Everyone is conscious of the enormous increase in this type of accident. Table X shows the geographic distribution of motor vehicle fatalities in the United States by place of residence of the victims. In addition to these deaths there are over a million nonfatal automobile accidents in the United States. There may be a great many more than the police and other authorities are able to learn about. The figure of over one million is obtained from the records of law-enforcement officers and there are many accidents which are never recorded.

In the causation of motor vehicle accidents both pedestrians and

TABLE X

MOTOR VEHICLE DEATHS BY STATES, 1946

Rates are per 100,000 population

State	*Number of deaths*	*Rate*	*State*	*Number of deaths*	*Rate*
Alabama	766	27.3	Nebraska	289	22.7
Arizona	190	30.6	Nevada	64	47.3
Arkansas	367	19.5	New Hampshire	100	19.3
California	3,770	39.6	New Jersey	757	17.6
Colorado	361	31.8	New Mexico	186	35.2
Connecticut	264	13.4	New York	2,096	15.3
Delaware	76	26.9	North Carolina	1,052	28.9
District of Columbia	98	11.6	North Dakota	144	26.8
Florida	714	30.9	Ohio	1,823	25.0
Georgia	809	25.9	Oklahoma	539	24.2
Idaho	182	34.8	Oregon	493	34.0
Illinois	1,871	23.3	Pennsylvania	1,900	19.0
Indiana	966	25.6	Rhode Island	96	12.9
Iowa	549	21.6	South Carolina	627	32.9
Kansas	467	25.1	South Dakota	161	29.4
Kentucky	729	26.6	Tennessee	676	22.5
Louisiana	507	20.1	Texas	1,821	26.2
Maine	193	22.0	Utah	185	29.1
Maryland	429	19.6	Vermont	88	24.9
Massachusetts	618	13.5	Virginia	809	27.1
Michigan	1,576	26.0	Washington	633	28.1
Minnesota	588	20.8	West Virginia	406	22.5
Mississippi	479	22.8	Wisconsin	740	23.4
Missouri	830	22.0	Wyoming	105	40.0
Montana	166	34.8			
			Total, United States	33,411	23.9

SOURCE: National Office of Vital Statistics, U. S. Public Health Service.

motorists are at fault. The highest number of deaths of pedestrians in cities occurs when they cross the street between intersections. Children playing or walking in the street, are common causes of automobile accidents to drivers and children both. On the other hand, a fairly large number of pedestrian accidents occurs at intersections where the pedestrian, theoretically, has the right of way. These accidents are, of course, the fault of motorists.

Inebriety is an outstanding cause of motor vehicle accidents. Drunken drivers and drunken pedestrians are frequently the principal figures in the picture. A considerable percentage of drivers of cars

involved in fatal accidents show sufficiently high blood alcohol content to be classed as intoxicated.

The following are well recognized causes of motor vehicle accidents: driving at unsafe speed, failure to give right of way, driving while intoxicated, driving on the wrong side of the road, driving while drowsy, defective vision, vision obscured, highway obstructions, glaring lights of oncoming cars, mechanical imperfections in cars, defective brakes, old and unsafe tires, and psychological peculiarities of the driver.

Occupational Accidents: Accidents in and around places of work have received the most careful study because the industrial commissions of the various states have valuable data for such study. The causes of accidents in industry have been the result of supervisory defects, inability of the employee to follow instructions (usually due to poor judgment, ignorance or inexperience), poor discipline, lack of concentration, inattention, practical jokes, taking chances, taking short cuts, too much haste, sluggishness, fatigue, violent temper, excitability, weakness, or physical defects. Physical factors as causes of accidents have been on the decline because these can and have been improved. These physical factors are ineffectively guarded machinery or unguarded machinery, improperly piled or stored material, congestion of material, poor housekeeping, defective tools and equipment, lack of fire protection, lack of inflammable gas detectors in mines, lack of exits, unsafe floors, dangerous openings and other unsafe building conditions, improper ventilation, improper lighting, defective layout of operations, unwise layout of machinery, unsafe processes, improper dress or apparel, and many others.

In industry, the key person in accident prevention is the foreman or immediate supervisor of employees. He should be able to judge the the ability of an individual to do a given job, and give instructions as to the best method of performing a task (how to lift an object, run a machine, etc.)

Numerous pieces of personal equipment are of great value in protecting the workman against injury. Helmets or skull guards are usually made of laminated bakelite and worn to prevent head injuries. Such skull guards are sometimes equipped with electric lights and reflectors to give light in dark places. Goggles are used to prevent foreign bodies from entering the eyes and to protect against excessive light in welding. Safety shoes with a steel box under the leather of

the toe are used to prevent falling objects from injuring the toes. Shoes may be obtained with brass nails in soles and heels to prevent sparks in places where explosion is a possibility. Shin guards and arm guards are used to prevent injury in arms and legs. Asbestos clothing is used in certain industries where clothes may catch fire.

There is an abundance of equipment available to detect the presence of inflammable gases, noxious fumes and vapors and masks to protect against dust diseases, and industrial poisons.

The Accident-Prone Individual: A comparatively small group of people suffer the majority of accidents. Insurance companies have noticed this fact many times. The same people have the same types of automobile accidents over and over again. The accident-prone individual often has a fautly attitude toward others, is impulsive, irresponsible, fearful or may be well intentioned but show faulty judgment, failure to recognize potential danger, inability to keep attention constant, have slow reactions, and suffer from worry and depression.

Solving the Accident Problem: Education in safe habits and the development of such habits is the basis of accident prevention. Experts agree that the time to develop such habits is in childhood. Properly trained in the beginning the individual will be apt to act automatically to prevent accidents. Safety education is one of the most important subjects in any school curriculum and is gathering momentum as time goes on.

Safety education addressed to engineering students and practicing engineers pays large dividends for these men design appliances, tools, and equipment or lay out roads, bridges, and railroads or build automobiles, airplanes, and locomotives and are concerned with practically every object used by mankind.

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PUBLIC HEALTH ADMINISTRATION

The Development of Health Departments: In 1853 the state of Louisiana established the first state board of health to cope with a yellow fever epidemic in New Orleans. However, this board did very little for the control of yellow fever or any other disease and remained quiescent for some time. It was revived as late as 1898 and has been active only since then. Cities along the Atlantic sea coast had had health officers for some years and vital statistics of a sort had been collected. (See Fig. 1.)

The first effective state board of health was that of Massachusetts established in 1869. It has functioned uninterruptedly ever since. This board was the result of the work of Lemuel Shattuck, Chairman of the Board of Commissioners appointed by the legislature of Massachusetts in 1848, who made his first recommendations the following:

I. WE RECOMMEND *that the laws of the state relating to Public Health be thoroughly revised and that a new and improved act be passed.*

II. WE RECOMMEND *that a GENERAL BOARD OF HEALTH be established, which shall be charged with the general execution of the laws of the State, relating to enumeration, the vital statistics, and the public health of the inhabitants.*

III. WE RECOMMEND *that the Board, as far as practicable, be composed of two physicians, one counsellor at law, one chemist or natural philosopher, one civil engineer, and two persons of other professions or occupations; all properly qualified for the office by their talents, their education, their experience and their wisdom.*[1]

The details of the now-called Shattuck Report were made available by the Harvard University Press in 1948 in a facsimile edition printed from the original. The Shattuck report has interested students of

[1] *Report of a General Plan for the Promotion of Public and Personal Health,* Devised, Prepared and Recommended by the Commissioners appointed under a resolve of the Legislature of Massachusetts, relating to a Sanitary Survey of the State. Boston, Dutton and Wentworth, State Printers, 1850, pp. 109, 111, and 112.

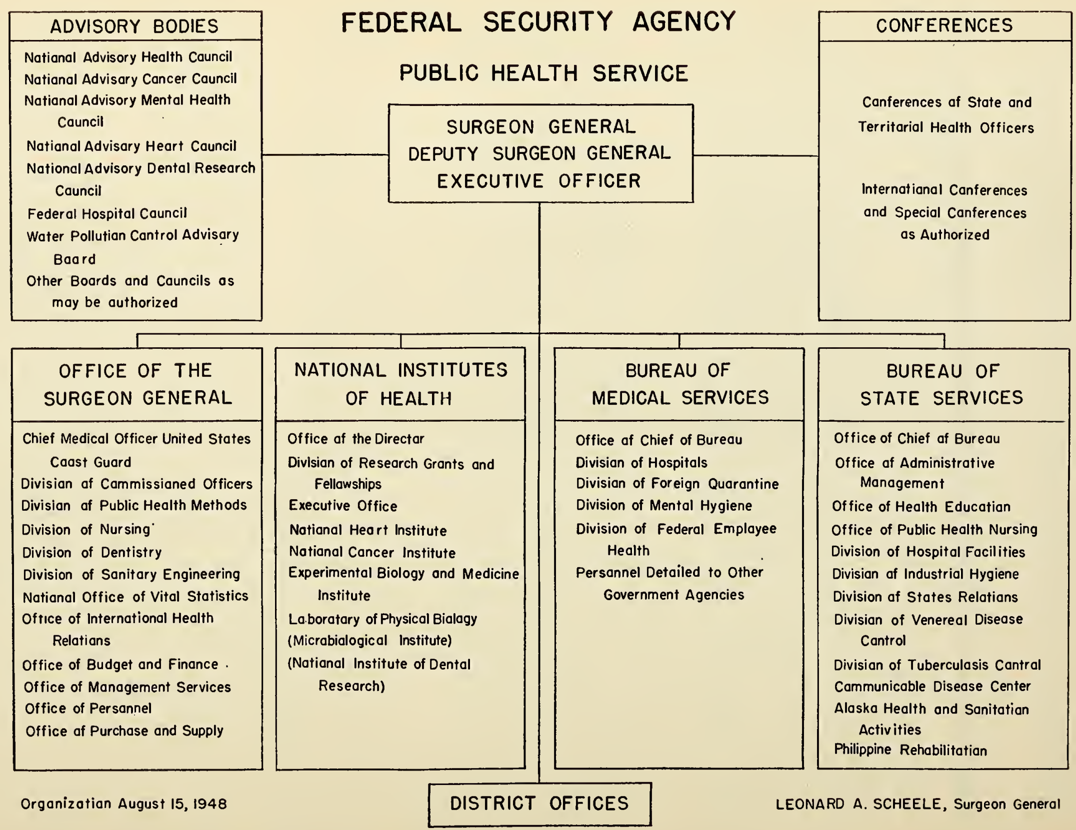

FIG. 100. Functional Chart of the United States Public Health Service. Divisions in parentheses were planned but were not in operation on August 15, 1948.

public health for a hundred years. Its 50 recommendations are as apropos of health problems today as they were in 1850.

Federal Health Services: A National Board of Health as such does not exist; there is no Federal Health Department with cabinet adviser such as exists in England and most European countries although such a department has been proposed. Health is nowhere mentioned in the Constitution of the United States. The supervision of health is a part of the broad police powers of the various states. The result has given rise to inequalities in public health activities in this country. When extensive investigations were made in both world wars certain inequalities were found to exist in the men called from different localities. (See Figs. 6, 7, 8, 9, 10, 11, 12, and 41.) Such inequalities are due, in part at least, to lack of educational opportunities offered by the more efficient health departments and voluntary health organizations and variation in the effectiveness of public health measures. Under the wise and efficient leadership of the United States Public Health Service public health has advanced to a remarkable point in this country. This leadership has been a slow growth but a steady one. This Service was established in the administration of John Adams on July 16, 1798. Its organization chart is shown in Fig. 100. This chart shows its first as well as its latest activity. Dr. Harry S. Mustard has described its beginnings concerned with Alexander Hamilton and the Treasury Department, and its further development.[2] It remained in the Treasury Department until very modern times.

The United States Public Health Service was first authorized in a bill "for the relief of sick and disabled Seamen." This bill provided that the relief was to be paid for by a deduction of 20¢ per month from the wages of each merchant seaman and such money was to be paid into the Treasury of the United States to be disbursed for the benefit of sick or disabled sailors. Later it was supported by general tax funds but remained in the Treasury Department. Its status in early years was uncertain. Indeed it really had no name until about 1870 when it was reorganized and called the Marine Hospital Service. Its first annual report was published in 1872. Under its first surgeon, Dr. John M. Woodworth, it began to concern itself with the promotion of health of seamen in 1874. By 1943, the aspect of medical care of

[2] Mustard, H. S. *Government in Public Health*. New York, The Commonwealth Fund, 1945.

seamen had expanded to include 26 Marine Hospitals of the first class with 6,500 beds, the beneficiaries to include many people other than seamen, and its expenditures had increased from $396,263.11 in 1872 to $59,764,250.78 in 1943.[3]

In 1878, the Marine Hospital Service was entrusted with the administration of maritime quarantine which, except for a short period, it has maintained ever since; the states have gradually withdrawn from the field of foreign quarantine. In 1890, Congress gave this Service interstate control of cholera, yellow fever, smallpox, and plague. In 1893, the Federal Government gave the Marine Hospital Service power to prevent the introduction of all infectious disease from a foreign country and from one state to another. In 1902, Congress regulated interstate commerce in viruses, serums, vaccines and other agents of immunization. The U. S. Public Health Service standardizes all of these. The name of the Service was changed twice; in 1902, it was called the "United States Public Health and Marine Hospital Service" and in 1912 it was designated by the name it now bears. In 1913, it obtained funds for field investigations in public health and used its funds for co-operative work with various state health departments. From 1917 to 1935, the U. S. Public Health Service established relationships with state and local health departments. Grants-in-aid were made to certain states and local communities which, although temporary, helped develop stronger departments in various places.

In 1935, Congress passed the Social Security Act and in 1939 placed the U. S. Public Health Service in the Federal Security Agency. With the passage of the Social Security Act, federal activities in public health began to expand and monies were appropriated for the improvement of local health units where needed. The amount alloted for each state was determined on the basis of population, special health problems, and financial needs of the respective states. In making the grants the states were required to appropriate certain funds to match or partially match the federal grants. In 1938, the Service was instructed to distribute funds among the states in an act to control venereal diseases.

Other federal departments concerned with health activities are the following: The Department of Labor (two bureaus, The Bureau of Labor Statistics and the Children's Bureau). The former has con-

[3]*Ibid.*, p. 47.

cerned itself with study and research in the field of industrial hyigene, housing of industrial workers, and certain diseases common among them. The latter (created in 1912) has had a marked effect upon infant and maternal welfare. At first the Children's Bureau was ordered merely to investigate and report to Congress but with the passage of the Sheppard-Towner Act in 1921 it was made the administrative agency (with certain collaboration) for giving aid to states for the benefit of women and children specifically. This act was repealed in 1927 but the Social Security Act of 1935 greatly increased the importance of the Children's Bureau by making available for it funds to be distributed to the states for maternal and child health services, aid for crippled children, and, during World War II, emergency maternity and infant care for the wives and children of enlisted men in the various services. Over 40 agencies of the federal government are concerned with health or medical activities. Some are well administered while others are not. In the Department of Agriculture there are the Bureaus of Animal Industry, Home Economics, Dairy Industry, Entomology, and Plant Quarantine. Much of the material presented under specific headings above has come from certain of these bureaus as indicated. In the Department of Commerce the Bureau of the Census gives basic data for studies in vital statistics. The former Division of Vital Statistics is now called the National Office of Vital Statistics and is located in the United States Public Health Service. (See Fig. 100.) In the Department of the Interior, Office of Indian Affairs, sanitation and medical care for Indians is provided and in the Bureau of Mines, safety and health conditions of miners is supervised. In addition to the U. S. Public Health Service, the Federal Security Agency also contains the Pure Food and Drug Administration (this was formerly in the Department of Agriculture) and the Office of Education. The Veterans Administration also concerns itself with the health and welfare of veterans of all wars.

Other departments, bureaus, divisions, etc. contain specialized agencies concerned with health. For example the Post Office Department refuses use of the mails to those sending harmful drugs or for the illegal practice of medicine. The medical departments of the armed services provide medical care, supervise sanitation, publish pamphlets on hygiene and sanitation and do research on certain problems in military medicine.

State Boards of Health or Health Departments: The pattern of a state health department is often set through the advice and counsel of the U. S. Public Health Service and the American Public Health Association, an unofficial health organization composed of health officers and others working in the field of health or health education.

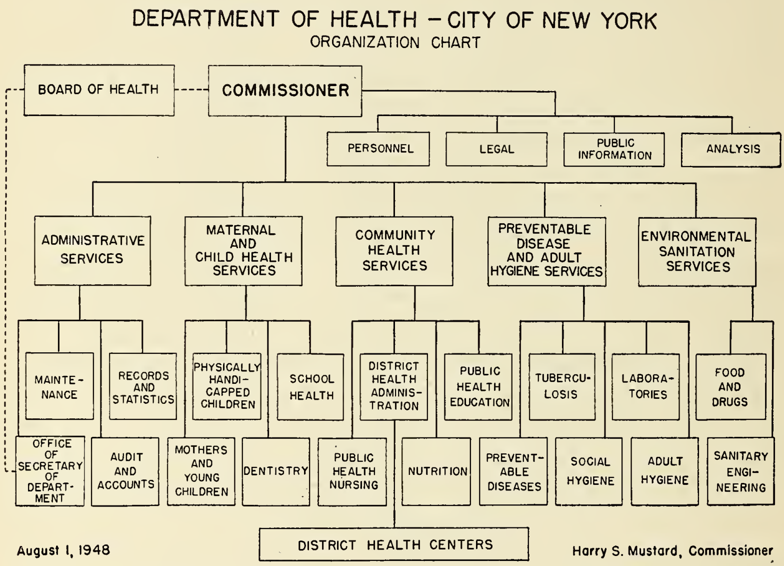

Fig. 101. Functional Chart of the New York City Health Department.

It is evident that the 48 states of the United States have different health problems but there is a certain stability to such health departments and the general patterns are very similar. Local health departments often preceded state health departments, sometimes by many years, and in some places today, where one city dominates a state or county the leadership in health activities is often centered in that city. Also many different agencies in a state government often carry on health work.[4]

[4] Mountin, J. W. and Flook, Evelyn. "Distribution of Health Services in the Structure of State Government: The Composite Pattern of State Health Services." *Public Health Reports.* Washington, Government Printing Office, v. 56, p. 1676, 1941.

According to the American Public Health Association the following are the desirable minimum functions of a state health department:

1. Study of state health problems and planning for their solution as may be necessary.
2. Co-ordination and technical supervision of local health activities.
3. Financial aid to local health departments as required.
4. Enactment of regulations dealing with sanitation, disease control, and public health, which have the force of law throughout the state.
5. Establishment and enforcement of minimum standards of performance of work of health departments, particularly in communities receiving state aid for public health.
6. Maintenance of a central laboratory, and where necessary branch laboratories, for the standard functions of diagnostic, sanitary, and chemical examinations; production or procurement of therapeutic and prophylactic preparations, and their free distribution for public health purposes; establishment of standards for the conduct of diagnostic laboratories throughout the state; laboratory research into the causes and means of control of preventable diseases.
7. Collection, tabulation, and publication of vital statistics for each important political or health administrative unit of the state and for the state as a whole.
8. Collection and distribution of information concerning preventable diseases throughout the state.
9. Maintenance of safe quality of water supplies and control of the character of the disposal of human waste for all communities of the state.
10. Establishment and enforcement of minimum sanitary standards for milk supplies.
11. Provision for services to aid industry in the study and control of health hazards due to occupation.
12. Prescription of qualifications for certain public health personnel.[5]

In order to accomplish these functions certain subdivisions of the state health department are usually established such as bureaus of vital statistics, sanitation, communicable disease control, tuberculosis, venereal diseases, laboratory services, nutrition, hygiene of maternity and young childhood, school hygiene, industrial hygiene, public health nursing, health education, dental problems in public health, mental hygiene, cancer, heart council and other departments. The organization usually varies with the importance of various conditions and problems in different parts of the country.

[5] "Desirable Minimum Functions and Organization Principles for Health Activities." *Year Book for 1940–41,* p. 49. New York, American Public Health Assn.

What is a Public Health Problem? There is a rather general acceptance of the idea that a health problem becomes a public health problem when government can solve or help solve it. The most obvious practice belonging in the field of public health is the control of communicable diseases. However well the individual may succeed in developing and maintaining a high degree of personal health, he finds that unless there is an efficient control of his environment, which tends to protect him, his health is in constant jeopardy. For example, a person traveling through a region which does not have proper sanitation must be constantly on guard or he will become ill. Unless public health has advanced to a high degree, he must avoid drinking water or he may develop an enteric disease. If tuberculosis is prevalent, especially among food handlers, he may become infected with that disease. It is difficult to boil his own water and cook all his own food especially if he is riding on a train or touring in a motor car. He may drink beer, pop, or some other beverage which has been under enough pressure to kill microbes. The quality of beverages may be very uncertain, however, and it is better for him to carry his own boiled drinking water. In some places very little milk has been pasteurized and he must avoid drinking that or eating products derived from milk. Fresh fruits and fresh vegetables may be fertilized with substances derived from human excreta (there are many such places in the world, India and China particularly) and he must avoid such articles. Finally his diet becomes extremely restricted and he usually becomes ill in spite of all his precautions. Public health supervision is therefore necessary for the maintenance of health in the individual.

As time passes the public health picture changes, such changes are shown in Figures 1, 40, 56, 59, 96, and 109. Goverment (and private medical practice) solves one problem after another and passes on to tackle new or neglected ones. When lives are saved by certain general practices in infancy and childhood and various communicable diseases are brought under control, health workers are confronted with the fact that people still die too young. They attempt to postpone such deaths.

Frequently a careful scientific study, backed by governmental resources, points the way to improved general health conditions which can be brought about by health education. It is right and proper that health departments engage in educational activities, employ full-time health educators, work for health education in the schools, and give

their advisory support to such education. It is also a well-recognized function of a health department to advise practicing physicians of latest developments in the field of what might be called "wholesale medicine." [6]

A number of factors can be decided upon as important in a public health program. The first group of factors are concerned with vital statistics which is discussed in Chapter 17. Others include any preventable condition that impairs the health of man.

Any disease that has a high mortality rate is of importance to the community. As was pointed out in Chapter 2 communicable diseases were responsible for most of the deaths in the nineteenth century. Public health activities brought death rates from these diseases down. Now the degenerative diseases, which are imperfectly understood, are the principal causes of death and attention is focused on them.

Any disease which has a high morbidity rate is also of importance to the community, even though its mortality rate may be negligible. The common cold is such a disease. It causes loss of efficiency, predisposes to serious complications, and makes a large number of people uncomfortable. Educational activities of the health department may be directed toward minimizing the seriousness and spread of this condition.

Any disease which has a high case fatality rate is of importance to the community and the concern of the health department. Rabies is such a disease as its case fatality rate is 100 per cent. Tetanus also has a high case fatality rate, although occasionally cases of tetanus recover. Small children are now routinely immunized against tetanus by most up-to-date pediatricians as they are apt to be injured and may develop the disease.

Any disease which is followed by a long period of disability requiring months or years of hospitalization, such as tuberculosis, is of concern to the community and the health department. Its early detection

[6] This was done by the late Dr. Wm. H. Park, former Health Commissioner of New York City who started a campaign against diphtheria as early as 1893. This campaign followed by most health officers and pediatricians has culminated in the brilliant achievement of reducing death rates from that disease from 40 per 100,000 population in 1900 to 0.9 in 1946. He advocated throat cultures as a means of establishing the diagnosis and period of infection in 1893. In 1917, he developed widespread immunization with toxin-antitoxin in diphtheria prevention. After 1924, when Ramon perfected an*a*toxin, or toxoid, the use of this substance was adopted as a universal method of active immunization for diphtheria. (See Fig. 32.)

is of paramount importance; the longer it remains untreated in the community the greater is the danger of its spread. Not all cases of tuberculosis will require long hospitalization because modern methods of treatment often shorten the periods of disability. Mental disease is a notable example of this type, also.

Any disease which is apt to have important complications and sequellae is also important. Rheumatic fever, syphilis, and poliomyelitis are examples of this type.

Diseases which spread rapidly such as smallpox, influenza, dengue fever, and the so-called childhood diseases are also of public health importance and interest. In epidemic form they result in high case fatality rates, at times. This is especially true of smallpox. At least one pandemic of influenza resulted in many deaths in 1918 and 1919. (See Fig. 39.) Sometimes measles is a very severe disease which causes deaths.

Any disease which is apt to be fatal to children or young adults is also considered of prime importance. Perhaps the outstanding example here is death from violence. Fatalities from the motor vehicle often occur to young children or immature drivers. Also war takes a sizeable number of young men. Those factors which contribute to violent death, such as alcoholism, are of interest to health workers. Another example of a disease apt to be fatal to young children is whooping cough in the very young.

Of course any preventable condition that impairs health is considered of importance to a health department. Many times the efforts of the official health agencies are supplemented by voluntary health organizations many of which have a special interest in the various health problems.

Voluntary Health Organizations: A number of professional and non-official health organizations work actively in the field of promotion of health. Many of them are engaged in health education activities and have material for teaching purposes which is available sometimes at small cost or no cost at all. The names and addresses of some of the outstanding voluntary health agencies are as follows.

American Association for Health, Physical Education, and Recreation, 1201 Sixteenth Street, N.W., Washington, D. C.; *American Cancer Society,* 47 Beaver Street, New York, N. Y.; *American Dental Associa-*

tion, 212 East Superior Street, Chicago, Ill.; *American Dietetic Association,* 620 North Michigan Avenue, Chicago, Ill.; *American Eugenics Society,* 1790 Broadway, New York, N. Y.; *American Hearing Society,* 817 Fourteenth Street, N.W., Washington, D. C.; *American Heart Association,* 1775 Broadway, New York, N. Y.; *American Home Economics Association,* 620 Mills Building, Washington, D. C.; *American Hospital Association,* 18 East Division Street, Chicago, Ill.; *American Medical Association,* 535 North Dearborn Street, Chicago, Ill.; *American National Red Cross,* 17th Street between D and E Streets, N.W., Washington, D. C.; *American Public Health Association,* 1790 Broadway, New York, N. Y.; *American Social Hygiene Association,* 1790 Broadway, New York, N. Y.; *Child Study Association of America,* 221 West 57th Street, New York, N. Y.; *Child Welfare League of America,* Inc., 130 East 22nd Street, New York, N. Y.; *Commonwealth Fund,* 41 East 57th Street, New York, N. Y.; *Department of Visual Instruction of the National Education Association,* 1201 Sixteenth Street, N.W., Washington, D. C.; *Health and Welfare Department of the Metropolitan Life Insurance Co.,* 1 Madison Avenue, New York, N. Y.; *Milbank Memorial Fund,* 40 Wall Street, New York, N. Y.; *National Committee for Mental Hyigene,* 1790 Broadway, New York, N. Y.; *National Committee for Education on Alcoholism,* New York Academy of Medicine, 2 East 103rd Street, New York, N. Y.; *National Congress of Parents and Teachers,* 600 South Michigan Boulevard, Chicago, Ill.; *National Foundation for Infantile Paralysis,* 120 Broadway, New York, N. Y.; *National Health Library of the National Health Council,* 1790 Broadway, New York, N. Y.; *National Organization for Public Health Nursing,* 1790 Broadway, New York, N. Y.; *National Recreation Association,* 315 Fourth Avenue, New York, N. Y.; *National Research Council,* 2101 Constitution Avenue, Washington, D. C.; *National Safety Council,* 20 North Wacker Drive, Chicago, Ill.; *National Society for the Prevention of Blindness,* 1790 Broadway, New York, N. Y.; *National Tuberculosis Association,* 1790 Broadway, New York, N. Y.; *Rockefeller Foundation,* 49 West 49th Street, New York, N. Y.; *Society for Curriculum Study,* Stanford University, Cal.; *Society for Research in Child Development,* 2101 Constitution Avenue, N.W., Washington, D. C.; *United Nations, World Health Organization,* 350 Fifth Avenue, New York, N. Y.

Voluntary health organizations often demonstrate the value of cer-

tain phases of health work which is later absorbed by the official organization. In order to prevent duplication and allow for absorption the voluntary agency usually confines its efforts to activities that the health department is not yet ready to undertake. Activities like the prevention of tuberculosis which naturally falls into the hands of the health department are often augmented by the voluntary agency to a degree not possible for the official organization.

Difficulties and Obstacles in the Way of Public Health Program: The first difficulty or obstacle in the way of public health progress is usually inadequate budget in most communities. It is true, that within certain limits, health is a purchasable commodity yet the taxpayer is apt to be niggardly in the appropriation of enough money to do an optimum job. If money is not spent in disease prevention then it must be spent for the treatment of avoidable illness. Often the results of neglect are extremely costly.

Sometimes health departments are manned by personnel not trained for the extremely scientific nature of the job to be done. The merit system is not always followed and some health department appointments are made on the basis of a spoils system that may be in vogue. Lay health officers often do not possess the necessary qualifications for the positions to be filled. There are some lay health officers and those appointed with a political objective in mind who are competent but such are in the minority.

Often there is meager knowledge as to how a disease may be controlled. In spite of the great amount of research work done on poliomyelitis just how to prevent the disease is unknown.

The methods of control of some diseases may be well known yet the control be difficult by a health department or any other governmental agency. An example of this type is syphilis, which is probably the most prevalent disease in the United States. (See Figs. 10 and 11.) Six per cent of the first million selectees examined in World War II had clinical or serological evidence of syphilis. The disease is probably as prevalent today as it was in 1941 in spite of the fact that the disease has been so intensively studied that its cause, modes of transmission, the pathological changes it produces in the body, methods of prevention, methods of treatment, and many other factors are well known.

An attitude of indifference on the part of individuals keeps some

diseases alive. The common cold is an example of this kind. Also mild cases of influenza and other readily communicable diseases.

Sometimes many of the public are antagnostic to the rules and regulations set down for the benefit of all. Drinking to excess was very popular among certain classes under prohibition. Even today the subject of inebriety often drives a motor car and causes death from accident. The individual with a head cold insists on spreading his microbes in crowded places. The infected prostitute often gets malicious satisfaction from spreading venereal disease.

The health intelligence of those who are in authority in certain communities, or are judges in the courts, or who decide cases as jurors is sometimes so deficient that health department workers can get no support in the prosecuting of their tasks. When courts do not support the reasonable regulations of health departments the health department cannot be effective.

Specialists in Public Health Administration: In recent years specialists have arisen within the field of public health who have contributed widely to the success of this movement. It is now impossible for each health officer to know everything in his field. An outline of the common specialties are these:

The General Public Health Administrator: His duties require: that he assume control of the financial management of his department, that he direct publicity for the health department, that he supervise the keeping and filing of records, that he be director of his own personnel, that he supervise the health education assumed by the health department, and that he supervise all other details such as correspondence and contacts with the public. He should be specially trained in public health work. Ideally, perhaps, he should be medically trained and be a Doctor of Public Health. Such positions are usually held by Doctors of Medicine, or Doctors of Public Health. There are many eminent men administering health departments who hold one or the other or both of these degrees.

The Epidemiologist: This specialist should be well trained in the science of epidemiology or the control of communicable disease. His duties are explained below: they are broad, interlocking, and require a peculiar ability. He need not necessarily be a physician, but he should have special training in bacteriology, pathology, and many of the medical subjects.

The Statistician: Vital statistics require some medical and a considerable amount of mathematical training. The specialist who deals with vital statistics, which will be discussed later, is a very important person in public health administration for he applies the yardstick or measure to the results of all administration in health. In the last analysis vital statistics will accurately measure the results.

The Laboratory Director: Experience has shown that scientific public health can only be practiced when the director of the laboratory, who is, after all, the most important scientist in the organization, can give reliable information to the other workers in the field. The laboratory is the heart of the public health work. Its director should be a well-trained scientist who has at his fingertips an extensive knowledge of physics, chemistry, biology, and especially bacteriology. He is a specialist who is at the same time versatile. Complete medicial training is a great asset to him, but requirements in the knowledge of the pure sciences are so great as to make additional clinical knowledge difficult to obtain.

The Sanitary Engineer: This specialist is required to have a certain amount of medical knowledge but to be primarily an engineer. He is usually a man especially trained in civil or sanitary engineering. He holds a place of equal importance to all the others in the health organization. Many times the sanitary inspectors come under his control and inspection is one of the most important functions in health work.

The Director of Public Health Nurses: This position is practically always held by a woman who is a registered nurse. She performs the important function of keeping in direct contact with cases and integrates them with all the other specialists in the department. Her position is equal in importance to the other heads of departments.

The Director of Clinics: Medical knowledge is essential to this position. In some cities or states the work is divided among a number of specialists: (1) pediatricians, (2) orthopedists, (3) tuberculosis specialists, (4) venereal disease specialists, (5) obstetricians or prenatal hygiene specialists, (6) psychiatrists, and others. The clinic heads perform the important function of helping to control communicable disease, and helping in the rehabilitation of social charges.

Other Specialists: These include a director of health education, di-

rector of industrial hygiene, quarantine officer, director of meat inspection, milk inspection, dental program and many others. Certain localities have problems peculiar to their situations.

Correlation: A well-organized health department pools all of its information and integrates all of its specialities into a practical working force. Each of the above, together with others performing some special function in a locality where such a function is required, are a link in a chain or a cogwheel in a machine. They must learn team work if the department is to obtain satisfactory results.

Division of Communicable Disease or Bureau of Epidemiology: Certain ideas of Hippocrates and Sydenham concerning the spread of diseases at various times of the year have persisted until the present time and some eminent physicians and epidemologists today credit weather with influencing, either directly or indirectly, the nature and cause of epidemic disease. This has sometimes led people astray. During the years when the French were trying to build the Panama Canal the climate was blamed for the pestilences which decimated the workers and caused abandonment of the whole scheme. The French were ignorant of the causes of transmission of malaria, yellow fever, and other insect-borne diseases. As soon as protective measures were taken against insects the region around the Panama Canal became one of the most healthful spots in the world as far as malaria or yellow fever were concerned. The building of the Panama Canal was a sanitary as well as an engineering triumph.

In addition to the weather, men in the past have felt that other and mysterious influences such as miasms, gases from the soil in certain places, stagnant water, filth, emanations from dead bodies, or exhalations from the sick as well as countless other indefinite things were responsible for epidemics. These emanations were supposed to be mostly air borne, and pesthouses were usually located some distance from a town or village.

As soon as the exact mode of transmission, the biological cause, and the factors influencing contagion are known, disease can be brought under control. This has been demonstrated time after time and such conditions as plague, cholera, typhus fever, typhoid fever, leprosy, and many others have all but disappeared from the civilized world.

Definition: Epidemiology is the study of the causes, modes of transmission and control of communicable disease and the factors influenzing such cases, modes of transmission, and control. The question of how many cases constitute an epidemic is a pertinent one. There is no hard and fast rule as to what constitutes an epidemic, but for all practical purposes an abnormally large number of cases of a communicable disease in a community may be called an epidemic. If a disease is not common in a certain locality and three or four cases make their appearance an epidemic may be said to exist. For example, several cases of poliomyelitis, especially if they are unrelated to each other, would be considered an epidemic whereas several cases of chicken pox or measles which are always present, would not be so considered.

Method of Procedure in Studying an Epidemic: The health officer of a community in bringing epidemic disease under control follows a definite procedure. First of all he discovers, either from the medical profession practicing in that community or from a survey, all of the known cases of the disease in question and their location in the community. In most places communicable disease is reported by the doctors to the health officer. Many cases are so mild, however, that a physician never sees them, consequently there are always more cases in a community than are reported to the health officer. The health officer must find these mild and missed cases. Secondly, he must gather and systematize certain facts from the cases. These facts vary with the disease in question but they should be considered the raw data from which his conclusions will be drawn. This data is usually obtained from the family physician or from a patient or a patient's family. Thirdly, the health officer analyzes the data on hand. This he may do in a number of ways but he usually follows at least two methods: (1) He sticks round head pins in or places spots on or circles around the location on a map where a case of a disease has occurred. He also connects cases with lines between the above where the relationship between these cases has been established. This map so marked is called a "spot map." (2) He plots a graph, usually daily or weekly, showing the number of new cases of an epidemic disease occurring on that day.

George B. Darling of the Department of Health of the City of Detroit has devised a master chart for epidemiological studies in that

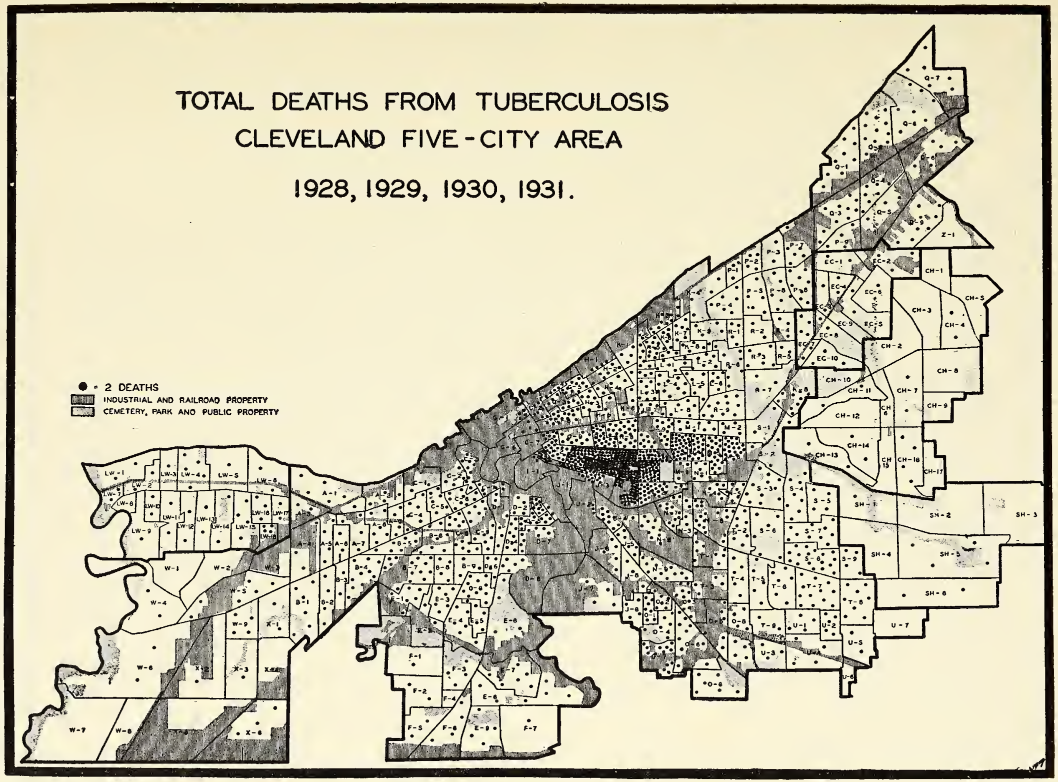

FIG. 102. A Spot Map showing location of the deaths from tuberculosis in Cleveland, Ohio, 1928–31.
Courtesy of Howard Whipple Green

city. For details concerning this chart the student is referred to the original article.[7]

The Spot Map: The origin of some diseases can be fairly definitely determined by a spot map. A notable example of this is milk-borne typhoid fever. After the epidemiologist has located his cases on a map he notices that they are strung out along the route of a certain milk wagon and not uniformily distributed over the community. The epidemiologist then looks for and expects to find the case or carrier on the farm or in the dairy who is the source of the infection.

In the case of water-borne disease he finds as did Dr. John Snow in 1854 (see p. 131) that the cases are grouped about a certain pump, or as Dr. Robert Koch found in investigating the Hamburg epidemic of cholera (see p. 132) that the cases are much more prevalent in Hamburg than in Wandsbech and Altona. Indeed, spots on the Hamburg map came up to the boundary of that city and practically stopped there. The main difference between the cities was in the filtration of water.

Nature of Epidemics: Each disease has certain peculiarities when it occurs in epidemic form which enables the epidemiologist to foretell roughly what is going to happen and to take proper measures to bring the epidemic under control. A few examples will serve to show this.

One of the oldest of epidemic diseases is smallpox. Epidemics of smallpox are independent of age, sex, occupation, race, or the sanitary surroundings of individuals who contract it. Before vaccination (see pp. 60-63) smallpox recurred in waves because after an epidemic most people were either dead or immune for life. Smallpox had to wait for a new generation of susceptible individuals for another epidemic. Nowadays smallpox occurs only among the unvaccinated which colors the picture differently and explains why smallpox sometimes gets started in a community and becomes a full blown epidemic before anyone realizes what disease is present. Smallpox in the adult who has been vaccinated once in childhood and not since then is very mild and not typical. Epidemics of smallpox can be controlled by wholesale vaccination of all the residents of a community. Indeed, there is no other epidemic disease which can be so satisfactorily handled as smallpox.

[7] Darling, George B. "Epidemiological Master Chart." *American Journal of Public Health,* v. 21, p. 665.

Influenza is another disease which comes in waves. In most epidemics it attacks about 40 per cent of the population in a short space of time. According to Rosenau[8] there have been fourteen major pandemics of influenza since the first authenticated one described by Willis and Sydenham in 1510. These occurred in 1510, 1557, 1580, 1593, 1729, 1732, 1762, 1788, 1830, 1833, 1836, 1847, 1889 and 1918. The same author points out that the disease was epidemic in the United States in 1627, 1647, 1729, 1732, 1762, 1782, 1789, 1811, 1832, 1850, 1857, 1860, 1874, 1879, 1889-90, 1916, 1918, and 1928. They have all varied greatly in their mortality, the one in 1918 having the greatest number of fatal cases (see Fig. 39). Epidemics have about the same general characteristics as those of smallpox, another contact disease. Unfortunately the immunity from an attack of influenza is not lasting but nevertheless the disease occurs in waves. This is difficult to understand (see p. 85). The control of epidemics depends primarily on the isolation of the cases, although carriers must be numerous.

Measles is another disease which occurs in wavelike epidemics. The waves occur every two or three years. When the disease visits a community from which it has been absent for a number of years it is usually rather severe in its nature. It is primarily a disease of young children, and one attack usually confers a life-long immunity. Occasionally it attacks adults who have had the disease in infancy. Adults who have never had measles are quite susceptible to the disease when it is present in epidemic form. Measles, German measles, mumps, chicken pox, and whooping cough are the five epidemic childhood diseases which sooner or later attack everyone. All of these diseases depend upon isolation and quarantine for control.

Diphtheria, one of the diseases of childhood, so called, also occurs in epidemic form at times, although it is coming under definite control (see Fig. 32). It frequently occurs in epidemic form in boarding schools, orphan asylums, military camps, jails, and similar places of concentration. It is much more severe in the colder climates during the winter months than in the tropics. In this respect it differs from certain other epidemic diseases. In addition to isolation and disinfection (which see) a sovereign and specific remedy exists in the form of diphtheria antitoxin (see pp. 67-70). All contacts with the patient may

[8] Rosenau, Milton J. *Preventive Medicine and Hygiene.*

be given antitoxin. It is, however, desirable to first give the Schick test to make sure that antitoxin is not being administered unnecessarily. Those who have a negative Schick test do not need antitoxin. The wholesale immunization with diphtheria toxoid may ultimately eradicate diptheria in civilized countries. Godfrey reports that the

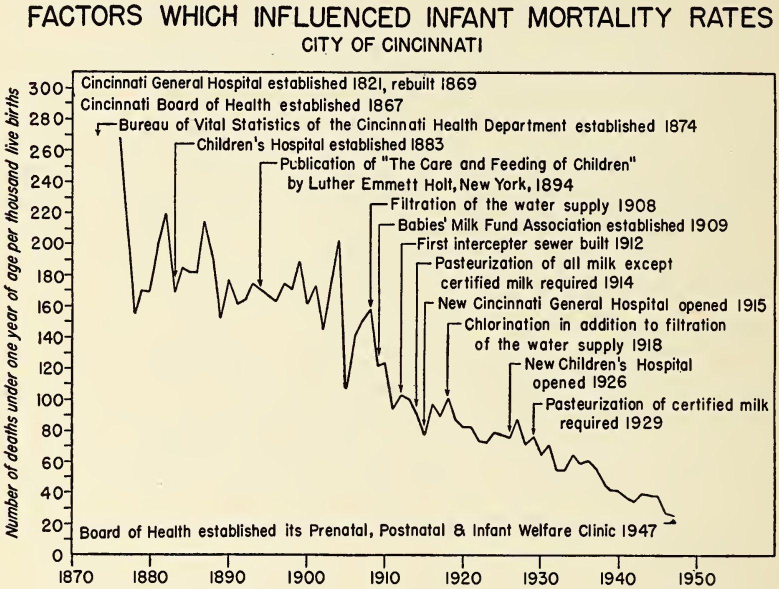

FIG. 103. Infant mortality rates have been declining steadily for years. A number of factors undoubtedly play a part one of which, the improvement in medical service, cannot be conveniently shown. The development of modern obstetrics and pediatrics is an important factor in reduced infant mortality rates.

most effective prevention of diphtheria consists in the inoculation of children under 5 years of age with toxoid. If 30 per cent or more of such children in any community are actively immunized an epidemic of diphtheria probably will not occur.[9]

Scarlet fever is an epidemic disease which varies greatly in its virulence in different epidemics. An antitoxin has been developed for the

[9]Godfrey, Edward S. "Study in the Epidemiology of Diphtheria in Relation to the Active Immunization of Certain Age Groups." *American Journal of Public Health,* v. XXII, p. 134.

treatment and prevention of this disease but is seldom used. Isolation and quarantine are still the sheet anchors of scarlet fever control, however.

All communicable disease has certain epidemiological peculiarities well understood by the epidemiologist. This specialist in preventive medicine is really a medical detective whose methods are scientific in nature, but his special talent or knack of detection seems to be inborn. No matter how much knowledge the public health worker has, he will not be successful as an epidemiologist unless he has unusual ability at deduction and a certain facility in using his imagination and reasoning. He does need the consultation service of other experts in public health, however, especially the statistician, the sanitary engineer, the laboratory scientist, and the clinician.

Division of Epidemiology in a Department of Health: The need for such a division or bureau has been pointed out a number of times and the larger health departments should and usually do include it. Ferrell suggests the following rules which are quoted from his article.[10]

1. There shall be a bureau or division dealing with epidemiology in each state health department co-equal with other essential divisions in the organization.

2. The function of this bureau or division, with respect to investigation of disease shall be

a. The analysis of morbidity statistics whether these be collected directly or through some other division.

b. The correlation of the mortality statistics obtained through the division of vital statistics with the morbidity data.

c. The securing of immediate information from the division of sanitary engineering or other divisions as to the prevalence of disease.

d. The use of laboratory data as a source of primary information as to the existence of communicable disease.

e. To secure special service from any division as to the causative factors of disease.

f. To classify, analyze, and interpret all available information with reference to disease, for administrative guidance in formulating sound plans of procedure and acquainting health agencies, the medical profession, and the public with the facts.

g. To conduct field investigations for the purpose of collecting or discovering facts essential to more effective control procedures.

h. To assist local authorities in epidemiological activities.

[10] Ferrell, John A. "Epidemiology in State and City Health Department." *American Journal of Public Health*, v. XX, p. 433.

3. The work of the division requires the services of professional, clerical, and field personnel.

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17

VITAL STATISTICS

As a measure of health work and progress the value of vital statistics cannot be overstated. Without them one works in the dark for he has no measure of the progress he is making. Vital statistics are a recent development in hygienic science for before the time of Captain John Graunt (1620-74) studies in birth and death rates and causes of death were not made to any great extent. It is true that censuses had been taken many times in the world's history but these enumerations were made mostly for the purpose of counting the people to determine the number able to bear arms or pay taxes. In ancient Greece, Solon established the custom of counting the people and classifying them as a basis for levying taxes. Moses is said to have taken a census of the Israelites about 1490 B.C. This was apparently repeated by King David about 1017 B.C. The word "census" is derived from the title "censors" the officers in ancient Rome entrusted with the duty of enumerating the citizens of Rome. William the Conqueror ordered a census which resulted in the famous Doomsday Book complied in England between 1085 and 1086. This book served as a basis of taxation until 1522 when the New Doomsday Book was compiled. In the United States a census has been taken every ten years since 1790 and has served as a basis for compiling vital statistics since that time.

Most authors set 1662 as the date of beginning of vital statistics with the publication by John Graunt of the book *Natural and Political Observations Mentioned in a Following Index, and Made Upon the Bills of Mortality.* He made an analytical study of the burials, marriages, and baptisms in the records of the parish clerks who had been compiling statistics for a century or more before that time. It was he who discovered, among other things, that more males than females were born and the infant mortality rate was very high.

Johann Peter Süssmilch (1707-67) army chaplain of Frederick the great of Prussia continued the work of John Graunt attempting a development of natural theology in his book *Die Göttliche Ordnung in*

Natural and *Political*

OBSERVATIONS

Mentioned in a following INDEX,

and made upon the

Bills of Mortality.

BY

Capt. *JOHN GRAUNT*,

Fellow of the *Royal Society*.

With reference to the *Government*, *Religion*, *Trade*, *Growth*, *Air*, *Diſeaſes*, and the ſeveral Changes of the ſaid CITY.

——— *Non, me ut miretur Turba, laboro,*
Contentus paucis Lectoribus. ———

The Fourth Impreſſion.

OXFORD,

Printed by *William Hall*, for *John Martyn*, and *James Alleſtry*, Printers to the *Royal Society*, MDCLXV.

Fig. 104. Facsimile of the title page of the first treatise on vital statistics.

From Pearl, *Medical Biometry and Statistics. Copyright W. B. Saunders Co.*

den Veräuderungen des Menschlichen Geschlects aus der Geburt, dem Tode und der Fortflauzung desselben erweisen, etc.

William Farr (1807-83) of Kenley, Stropshire, England is usually thought of as one of the greatest medical statisticians of all time. He considered a life table an instrument of investigation of primary importance. "A life table is a particular conventional method of presenting the most fundamental and essential facts about the age distribution of mortality." [1] Life tables serve as a basis for the industry known as life insurance, and will be discussed briefly later.

Raymond Pearl [2] credits Sir Francis Galton with being the founder of the new science of biometry—the measure of life and human life particularly—and Karl Pearson and W. F. R. Weldon the builders of the superstruction of this science.

When vital statistics are made they depend upon certain fundamental methods of collection for their practical use. The taking of a census or making a count is the oldest method historically of determining the population. It still serves as a basis for almost all vital statistics as will be seen later. It must be taken with reference to a specific instant, *i.e.,* a certain time on a certain day, for society is changing every instant of time and new babies are born or people are dying. In addition to this in certain areas of the United States (for example) careful registration of all births and deaths must be made. These areas are grouped together under the name of "The Registration Area of the United States." This area did not include the total area of continental United States, for certain states or parts of states did not require careful registration until 1933. Even though a state was not included in the registration area of the Untied States certain cities or counties within that state were so included (see Figure 105). Births and deaths are the fundamental facts registered. A careful check-up is possible with deaths, because a body must be disposed of, and if it cannot be disposed of without a permit and a consequent registration the record is very apt to be clear. On the other hand sometimes and in some places births are difficult of registration because of the carelessness of physicians and midwives in this respect. Indeed many children are

[1] Pearl, Raymond. *Introduction to Medical Biometry and Statistics,* p. 177. W. B. Saunders Co., Philadelphia, 1923.

[2] *Ibid.,* p. 41.

born without the aid of either physician or midwife and registration of these births is difficult to obtain. A check-up occurs of course at census-taking time. Deaths are listed according to the "International List of Causes of Death" which was adopted in 1855 and has been revised a number of times since then.[3]

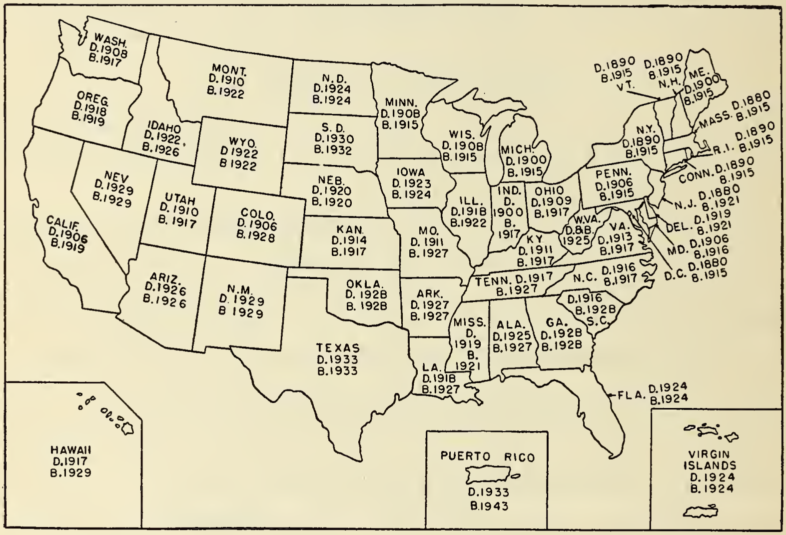

FIG. 105. Birth and Death Registration Area of the United States. The chart shown here indicates the dates when the various states joined the area. The reporting of deaths (D) and births (B) were required in the various states since the years indicated. Alaska has never formally joined the registration area but births and deaths are recorded there.

It should be noted in passing that the cause of death when recorded may not be the true cause at all, that post-mortem examinations are but rarely performed and more exact methods of diagnosis are not always at hand. The attending physician, medical examiner or coroner writes on the death certificate his diagnosis which he believes to be cor-

[3] In 1933 The International Commission for the Decennial Revision of the Nosological Nomenclature was established by a number of countries including the United States. The International List of Causes of Death was revised by the commission in 1935 and again in 1940 and published by the Government Printing Office, Washington, D. C.

MARGIN RESERVED FOR BINDING

THIS CERTIFICATE SHALL BE PRINTED LEGIBLY OR TYPEWRITTEN IN UNFADING INK.

V.S. 11

OHIO DEPARTMENT OF HEALTH
DIVISION OF VITAL STATISTICS
CERTIFICATE OF DEATH

Reg. Dist. No.________
Primary Reg. Dist. No.________

State File No.________
Registrar's No.________

1. PLACE OF DEATH
a. COUNTY
b. CITY OR VILLAGE (If outside corporate limits, write RURAL and give township)
c. LENGTH OF STAY (in this place)
d. FULL NAME OF HOSPITAL OR INSTITUTION (If NOT in hospital or institution, give street address or location)

2. USUAL RESIDENCE (Where deceased lived. If institution: residence before admission).
a. STATE
b. COUNTY
c. CITY OR VILLAGE (If outside corporate limits, write RURAL and give township)
d. STREET ADDRESS (If rural, give location)

3. NAME OF DECEASED (TYPE OR PRINT) a. (First) b. (Middle) c. (Last)

4. DATE OF DEATH (Month) (Day) (Year)

5. SEX

6. COLOR OR RACE

7. MARRIED, NEVER MARRIED, WIDOWED, DIVORCED (Specify)

8. DATE OF BIRTH

9. AGE (In years last birthday) | Under 1 Year: Months, Days | If Under 24 Hrs.: Hours, Min.

10a. USUAL OCCUPATION (Give kind of work done during most of working life even if retired)

10b. KIND OF BUSINESS OR INDUSTRY

11. BIRTHPLACE (State or foreign country)

12. CITIZEN OF WHAT COUNTRY?

13. FATHER'S NAME

14. MOTHER'S MAIDEN NAME

15. WAS DECEASED EVER IN U. S. ARMED FORCES?

16. SOCIAL SECURITY NO.

17. INFORMANT'S SIGNATURE

MEDICAL CERTIFICATION

18. CAUSE OF DEATH
Enter only one cause per line for (a), (b), and (c)

**This does not mean the mode of dying, such as heart failure, asthenia, etc. It means the disease, injury, or complication which caused death.*

I. DISEASE OR CONDITION DIRECTLY LEADING TO DEATH* (a)________

ANTECEDENT CAUSES

Morbid conditions, if any, giving rise to the above cause (a) stating the underlying cause last. DUE TO (b)________

DUE TO (c)________

II. OTHER SIGNIFICANT CONDITIONS
Conditions contributing to the death but not related to the disease or condition causing death.

INTERVAL BETWEEN ONSET AND DEATH

19a. DATE OF OPERATION

19b. MAJOR FINDINGS OF OPERATION

20. AUTOPSY? Yes ☐ No ☐

21a. ACCIDENT SUICIDE HOMICIDE (Specify)

21b. PLACE OF INJURY (e.g., in or about home, farm, factory, street, office building, forest, etc.)

21c. (CITY, VILLAGE, OR TOWNSHIP) (COUNTY) (STATE)

21d. TIME OF INJURY (Month) (Day) (Year) (Hour) m.

21e. INJURY OCCURRED While at Work ☐ Not While at Work ☐

21f. HOW DID INJURY OCCUR?

22. *I hereby certify that I attended the deceased from________, 19____, to________, 19____, and that death occurred at________m., from the causes and on the date stated above.*

23a. SIGNATURE (Degree or title)

23b. ADDRESS

23c. DATE SIGNED

24a. BURIAL, CREMATION, REMOVAL (Specify)

24b. DATE

24c. NAME OF CEMETERY OR CREMATORY

24d. LOCATION (City, town, or county) (State)

BIRTH NO.

Do not write in this space

NAME OF EMBALMER (LIC. NO.)

DATE REC'D BY LOCAL REG.

REGISTRAR'S SIGNATURE

25. FUNERAL DIRECTOR'S SIGNATURE (LIC. NO.)

FIG. 106. Death certificates in all states follow a pattern set by the National Office of Vital Statistics.

INFORMATION CONCERNING THE BURIAL OF DECEASED VETERANS

FUNERAL DIRECTORS ARE REQUIRED BY LAW TO FURNISH THE FOLLOWING ADDITIONAL INFORMATION ON A VETERAN'S CERTIFICATE OF DEATH

Name of deceased____________________

Date of birth__________ Date of death__________ Date of burial__________

Name of War or dates of service____________________

Was deceased honorably discharged?__________ Date__________

Rank or grade at discharge____________________

Service (as Army, Navy, Marine, Coast Guard, Woman's Army Corps, etc.)__________

Organization (as Regiment, Battalion, Fleet, Squadron, Command, Wing, Station, Group, etc.)__________

Unit in Organization (as Company, Battery, Ship, Flight, etc.)__________

Branch of service (as Infantry, Coast Artillery, Airborne Engineers, etc.)__________

Name of Cemetery____________________

Location of Cemetery

County____________________

Township____________________

Village____________________

City____________________

Name or number of section in cemetery__________

Number of lot____________________

Number of grave____________________

Information relative to a deceased veteran may be secured from the Veteran's Discharge Papers

Fig. 106A. Reverse of Ohio Certificate of death.

rect. In some cases, however, he is undoubtedly wrong. Many suspect that the high mortality from heart disease is more apparent than real, that many times the cause of death is given as heart failure when it may be some latent disease such as aneurism, syphilis, interlobular pneumonia, status thymico-lymphaticus or any one of a number of diseases difficult to diagnose.

After the cause of death has been established statistics are compiled using, as a rule, some unit of population as a measure, *e.g.*, most death rates are compiled per 100,000 of population in the community for the year in question. The population except for the census years is usually estimated.

Rates: The following is an outline of the essential facts usually compiled in vital statistics:

A. *Death Rates*[4] *(Mortality rates).*

1. Observed actual death rates obtained by the direct application of a general equation $R = K\left(\frac{a}{a+b}\right)$ (1)

   without assumptions.

   R = the death rate
   K = a constant
   a = the number of times the event actually occurs
   b = the number of times it might occur but does not
   $a + b$ = the whole number of exposures to the risk of its occurrence

   a. Crude death rates.
   b. Specific death rates.
   c. Infant mortality rates.
   d. Case fatality rates.
2. Theoretic death rates based upon certain assumptions.
   a. Standard (or standardized) death rates.
   b. Corrected death rates.

B. *Birth rates (Natality rates).*

1. Observed actual birth rates obtained from equation (1).
   a. Crude birth rates.
   b. Specific birth rates.
2. Theoretic birth rates based upon certain assumptions.
   a. Standardized birth rates.
   b. Corrected birth rates.

C. *Morbidity rates (Illness rates).*

1. Observed, actual.
   a. Crude.
   b. Specific.

D. *Marriage rates.*

[4] Pearl, *op. cit.*

E. *Divorce rates.*

Ratios. The general formula for a ratio is this:

$$Ro = K\left(\frac{a}{c + d}\right) \qquad (2)$$

Ro = a ratio
K = a constant
a = the number of times an event of some specific kind occurs
$c + d$ = the number of times some other kind of event, in general different from the "a" event occurs, although in some cases $c = a$

In general there are two kinds of ratios usually given in vital statistics. (1) Death rates and (2) Birth-death ratio or vital index.

Crude Death Rates: In crude death rates equation (1) above becomes:

$$Rc = K\left(\frac{D}{P}\right) \quad \text{where}$$

Rc = crude death rate
K = a constant usually 100,000
D = deaths from all causes
P = total population of the area in which the death occurred, equals:

$$D + (P - D) = P$$

Example: In 1931 the population of the registration area of the United States was 119,421,000 (P in the formula above) and the number of deaths was 1,322,587 (D in the formula above). Find the crude death rate per 1,000 population (K = 1,000 in the above formula).

$$\text{Crude death rate} = 1{,}000\left(\frac{1{,}322{,}587}{119{,}421{,}000}\right) = 11.1$$

The crude death rate from a particular cause or group of causes only becomes

$$R'c = K\left(\frac{D'}{P}\right) \quad \text{where}$$

$R'c$ = crude death rate from a particular cause (or group of causes)
K = a constant usually 1,000 or 100,000
D' = the number of deaths from a particular cause
P = the total population of the area in which the deaths occurred

Example: A certain city with a population of 310,120 in 1932 had 222 deaths from tuberculosis (D' in the above formula) in that year. Find the crude death rate per 100,000 population. Substituting in the formula above we have:

$$\text{Crude death rate from tuberculosis} = 100{,}000\left(\frac{222}{310{,}120}\right) = 71.5$$

These crude death rates are very crude indeed and give only a rough idea of the trend of mortality. Often they are good enough for com-

parative purposes because they give the trend of mortality, after a fashion, in a certain community. If a community's population remains fairly stable in its grouping of the various age groups and of the two sexes, a rough idea of the results of public health measures may be estimated. For example, much debate has been going on in recent years as to the increase in cancer, heart disease, and other diseases of degeneration. (See Table XI.)

Table XI would seem to indicate that deaths from certain degenera-

TABLE XI

CRUDE DEATH RATES FROM CERTAIN DEGENERATIVE DISEASES, RATES PER 100,000 POPULATION

Registeration Area of the United States

Year in Which Death Occurred	*Cancer*	*Diabetes Mellitus*	*Apoplexy*	*Heart Diseases*	*Nephritis*
1900	64.0	11.0	106.9	137.4	88.6
1902	66.3	11.7	103.9	145.4	90.6
1904	71.5	14.2	108.6	163.7	102.4
1906	69.3	13.4	98.6	154.2	95.9
1908	71.5	13.8	95.6	152.0	91.0
1910	76.2	15.3	95.8	158.9	94.8
1912	77.0	15.1	91.9	158.7	99.7
1914	78.7	16.2	93.6	158.2	99.2
1916	81.0	16.9	94.7	167.2	103.1
1918	80.8	16.1	94.0	171.6	97.4
1920	83.4	16.1	93.0	159.6	88.8
1922	86.2	18.3	92.1	165.0	87.7
1924	90.4	16.4	97.2	175.7	87.8
1926	94.6	17.9	91.3	198.6	97.3
1928	95.7	19.0	92.0	207.7	94.9
1930	97.4	19.1	98.0	214.2	91.1
1932	102.3	22.0	87.5	224.1	87.4
1934	106.4	22.2	85.5	240.3	84.3
1936	111.4	23.7	91.0	266.6	83.5
1938	114.9	23.9	85.9	269.7	77.4
1940	120.3	26.6	90.9	292.5	81.5
1942	122.1	25.4	90.2	295.2	72.4
1944	129.1	26.4	93.7	315.4	69.2
1946	130.1	24.8	89.8	306.8	58.4

SOURCE: Official Government Figures.

tive diseases were on the increase. This may or may not be true, for the crude death rates do not give us sufficient data upon which to base an accurate opinion. For example, if we consider the increase in cancer, the population may be changing so that there are relatively more people reaching a period in life when they are apt to get cancer. Unless one has the specific death rates, which will be discussed below, he cannot tell whether cancer is on the increase or not, and how much.

Specific Death Rates. These imply the death rates in a specified class of the population and usually are divided according to age and sex. Sometimes they are also divided as to color. The general formula for a specific death rate is as follows:

$$Rs = K\left(\frac{De}{E}\right) \qquad \text{where}$$

Rs = specific death rate
K = a constant
De = deaths in a specified class of the population.
E = the number exposed to risk of dying in the same specified class of the population from which deaths come

EXAMPLE: In a certain city there were 320,121 white people and 34,018 Negroes in a given year. In that same year there were 219 deaths among the whites from tuberculosis, and 57 deaths among the Negroes. Find the specific death rates for each group, per 100,000 of that group.

In the above formula the constant K is 100,000 for both groups; De 219 in one case and 57 in the other; E 320,121 in one case and 34,018 in the other. The solution is:

$$\text{Death rate for tuberculosis (white)} = 100{,}000\left(\frac{219}{320{,}121}\right) = 68.4$$

$$\text{Death rate for tuberculosis (colored)} = 100{,}000\left(\frac{57}{34{,}018}\right) = 167.6$$

Specific death rates give much more exact information concerning the trends of mortality than the crude death rates. For example, the crude death rate for puerperal septicemia (childbed fever) for the year 1930 is given as 4.6 per 100,000 of the population and 6.5 per 100,000 in 1912. One cannot be too sure that there has been so marked a decrease unless he knows the relative number of young mothers in the two years, for men must be excluded because they do not bear children and women not in the child bearing period likewise. Indeed most of the unmarried women should probably be excluded as not exposed to the risk of pregnancy and hence to puerperal septicemia.

Infant Mortality Rates. The formula for infant mortality rates derived from general formula (1) above is:

$$Ri = \mathrm{K}\left(\frac{Di}{B}\right) \quad \text{where}$$

Ri = Infant mortality rate
Di = Deaths of infants under one year
B = Births

EXAMPLE: In 1932, there were in a certain group of large cities 439,919 live births, and 23,606 deaths of infants under one year. Find the infant mortality rate per 1,000 births. Substituting in the above formula we have:

$$\text{Infant mortality rate} = 1{,}000\left(\frac{23{,}606}{439{,}919}\right) = 53.66 \text{ per } 1{,}000 \text{ births}$$

Birth certificates are, or can be made to be, fairly reliable data upon which to base statistics. Unfortunately there are still many mothers who are not attended by licensed attendants (doctors and midwives) at the birth of their babies and some escape registration. Nevertheless the infant mortality rate of a community is apt to be the most sensitive index obtainable in that community.

Case Fatality Rates. These are figured from the following formula:

$$Rf = K\left(\frac{Dc}{C}\right) \quad \text{where}$$

Rf = case fatality rate
Dc = Deaths amongst recognized cases of the disease for which the rate is calcalculated
C = cases of the disease

EXAMPLE: In a certain hospital the number of cases of pneumonia admitted in one year was 236. Of this number 48 died of the disease. Find the case fatality rate.

$$\text{Case fatality rate} = 110\left(\frac{48}{236}\right) = 20.34 \text{ per cent}$$

These are usually figured for a hospital or in a physician's private practice, for of all the statistics collected by the state those for morbidity are the most unreliable. Physicians are extremely lax about reporting communicable diseases and in general other disease is usually not reportable. Case fatality rates usually are reported in per cent, *i.e.,* the constant K in the above formula is 100.

Standard, Standardized, or Corrected Death Rates: These are theoretic in nature and are based roughly on the expectation of life of each member of the community. Obviously this is hard to obtain but know-

MARGIN RESERVED FOR BINDING
THIS CERTIFICATE SHALL BE PRINTED LEGIBLY OR TYPEWRITTEN IN UNFADING INK.
N. B.—In case of more than one child at a birth, a SEPARATE RETURN must be made for each, and the number of each child, in order of birth, stated.
V.S. 2

OHIO DEPARTMENT OF HEALTH
DIVISION OF VITAL STATISTICS
CERTIFICATE OF LIVE BIRTH

Reg. Dist. No. ____________ Registrar's No. ____________

Primary Reg. Dist. No. ____________ Birth No. 134 -

1. PLACE OF BIRTH
 a. COUNTY
 b. CITY OR VILLAGE (If outside corporate limits, write RURAL and give township)
 c. FULL NAME OF HOSPITAL OR INSTITUTION (If NOT in hospital or institution, give street address or location)

2. USUAL RESIDENCE OF MOTHER (Where does mother live?)
 a. STATE b. COUNTY
 c. CITY OR VILLAGE (If outside corporate limits, write RURAL and give township)
 d. STREET ADDRESS (If rural, give location)

3. CHILD'S NAME (TYPE OR PRINT) a. (First) b. (Middle) c. (Last)

4. SEX

5a. THIS BIRTH Single ☐ Twin ☐ Triplet ☐

5b. IF TWIN OR TRIPLET (This child born) 1st ☐ 2nd ☐ 3rd ☐

6. DATE OF BIRTH (Month) (Day) (Year)

FATHER OF CHILD

7. FULL NAME a. (First) b. (Middle) c. (Last)

8. COLOR OR RACE

9. AGE (At time of this birth) YEARS

10. BIRTHPLACE (State or foreign country)

11a. USUAL OCCUPATION

11b. KIND OF BUSINESS OR INDUSTRY

MOTHER OF CHILD

12. FULL MAIDEN NAME a. (First) b. (Middle) c. (Last)

13. COLOR OR RACE

14. AGE (At time of this birth) YEARS

15. BIRTHPLACE (State or foreign country)

16. CHILDREN PREVIOUSLY BORN TO THIS MOTHER (Do NOT include this child)
 a. How many OTHER children are now living?
 b. How many OTHER children were born alive but are now dead?
 c. How many children were stillborn (born dead after 18 weeks pregnancy)?

17. INFORMANT'S NAME OR SIGNATURE

I hereby certify that this child was born alive on the date above stated at ....M.

18a. SIGNATURE

18b. SPECIFY IF M. D., D. O., OR OTHER

18c. ADDRESS

18d. DATE SIGNED

19. DATE REC'D BY LOCAL REG.

20. REGISTRAR'S SIGNATURE

21. DATE SEROLOGIC TEST FOR SYPHILIS

FOR MEDICAL AND HEALTH USE ONLY
(This section MUST be filled out)

22a. LENGTH OF PREGNANCY WEEKS

22b. WEIGHT AT BIRTH LB. OZ.

23. LEGITIMATE Yes ☐ No. ☐

24. CONGENITAL MALFORMATION Yes ☐ No. ☐

25. MOTHER'S MAILING ADDRESS

FIG. 107. Typical Birth Certificate.

MARGIN RESERVED FOR BINDING

For the purposes of the vital statistics act a stillbirth is an infant of at least four and one-half months of uterogestation whose sex can be determined, which after complete expulsion does not give evidence of heart action, breathing, or movement of voluntary muscles.

V.S. 4

OHIO DEPARTMENT OF HEALTH
DIVISION OF VITAL STATISTICS
CERTIFICATE OF STILLBIRTH

Reg. Dist. No.________ State File No.________
Primary Reg. Dist. No.________ Registrar's No.________

1. PLACE OF STILLBIRTH a. COUNTY	2. USUAL RESIDENCE OF MOTHER (Where does mother live?) a. STATE b. COUNTY
b. CITY OR VILLAGE (If outside corporate limits, write RURAL and give township)	c. CITY OR VILLAGE (If outside corporate limits, write RURAL and give township)
c. FULL NAME OF HOSPITAL OR INSTITUTION (If NOT in hospital or institution, give street address or location)	d. STREET ADDRESS (If rural, give location)

3. CHILD'S NAME (TYPE OR PRINT)

4. SEX	5a. THIS BIRTH Single ☐ Twin ☐ Triplet ☐	5b. IF TWIN OR TRIPLET (This child born) 1st ☐ 2nd ☐ 3rd ☐	6. DATE OF STILLBIRTH (Month) (Year)

7. FATHER'S NAME a. (First)	b. (Middle)	c. (Last)	8. COLOR OR RACE
9. AGE (At time of this birth) YEARS	10. BIRTHPLACE (State or foreign country)	11a. USUAL OCCUPATION	11b. KIND OF BUSINESS OR INDUSTRY
12. MOTHER'S MAIDEN NAME a. (First)	b. (Middle)	c. (Last)	13. COLOR OR RACE

14. AGE (At time of this birth) YEARS	15. BIRTHPLACE (State or foreign country)	16. CHILDREN PREVIOUSLY BORN TO THIS MOTHER (Do NOT include this child) a. How many children are now living?	b. How many children were born alive but are now dead?	c. How many OTHER children were stillborn (born dead after 18 weeks pregnancy?)
17. INFORMANT'S SIGNATURE				

18a. LENGTH OF PREGNANCY WEEKS	18b. WEIGHT AT BIRTH LBS. OZS.	19a. LEGITIMATE Yes ☐ No ☐	19b. DATE SEROLOGIC TEST FOR SYPHILIS

CAUSE OF STILLBIRTH State only morbid conditions causing fetal death (Do not use such terms as Stillbirth, Prematurity, Asphyxia, etc.)	20a. FETAL CAUSES
	20b. MATERNAL CAUSES

21. STATE ANY COMPLICATIONS OF PREGNANCY AND LABOR	22. STATE ALL OPERATIONS FOR DELIVERY

I hereby certify that I attended the birth of this child who was born dead on the date stated above at ....m.	23a. ATTENDANT'S SIGNATURE (Specify if M.D. or D.O.)		23b. DATE SIGNED
	23c. ATTENDANT'S ADDRESS	If NOT attended by physician	24. SIGNATURE OF AUTHORIZED OFFICIAL TITLE

25a. BURIAL, CREMATION, REMOVAL (Specify)	25b. DATE	25c. NAME OF CEMETERY OR CREMATORY	25d. LOCATION (City, town, or county) (State)
DATE REC'D BY LOCAL REG.	REGISTRAR'S SIGNATURE	26. FUNERAL DIRECTOR (Lic. No.)	

FIG. 108. Typical certificate of Stillbirth.

ing the specific death rates for each age group and the number in that group theoretically one could calculate how many should be expected to die and from what cause. In 1895, the International Statistical Institute recommended that to facilitate the comparison of death rates the population of Sweden in 1890 be used as a standard population as far as rates are concerned. The method of calculation being somewhat complicated, and the ordinary lay student not coming in contact with these figures, as a rule, a detailed consideration of this rate is omitted here. (For further information see appropriate works on the subject of vital statistics listed at the end of this chapter.)

Birth Rates. The formula for the crude birth rate of any locality is:

$$Rb = K\left(\frac{B}{P}\right) \quad \text{where}$$

Rb = the crude birth rate
K = a constant (usually 1,000)
B = the number of births exclusive of still births in a given time (*e.g.*, a year)
P = the total living population

EXAMPLE: In 1930 the census gave the following figures for Chicago, Ill., and Boston, Mass. Population of Chicago 3,392,700; of Boston 782,000. Number of live births in Chicago 58,083; in Boston 18,015. Find the crude birth rates in these two cities per 1,000 population, for 1930.

$$\text{Crude birth rate for Chicago} = 1{,}000\left(\frac{58{,}083}{3{,}392{,}700}\right) = 17.12 \text{ per } 1{,}000 \text{ population}$$

$$\text{Crude birth rate for Boston} = 1{,}000\left(\frac{18{,}015}{782{,}000}\right) = 23.04 \text{ per } 1{,}000 \text{ population}$$

This is the birth rate usually given but it is very crude indeed. If one were to take the birth rate in a town the population of which was predominately male (and there are and were such) the birth rate would be very low and not indicative of the fertility of the women of that town at all. To get a more accurate measure he should have to use a specific birth rate formula and take into account the women only and possibly also only the married women for after all they are the ones expected to have children. The formula then would become:

$$Ra = K\left(\frac{B}{Pm}\right) \quad \text{where}$$

Ra = specific birth rate
B = number of births (excluding stillbirths) in a given time (a year)
Pm = population of married women

EXAMPLE: In 1930 the census showed that there were 754,256 married women in

Chicago, and 149,209 married women in Boston. Using the data in the previous example find the specific birth rates for Chicago and Boston in 1930. Using the formula above we have

Specific birth rate for Chicago $- 1{,}000 \left(\frac{58{,}083}{754{,}256}\right) = 77.01$ per 1,000 married women

Specific birth rate for Boston $= 1{,}000 \left(\frac{18{,}015}{149{,}209}\right) = 120.7$ per 1,000 married women

Both this example and the preceding one indicate that the women of Boston are more fertile than those of Chicago, but by the last example we note that they are more fertile than the former example would seem to indicate. In other words $\frac{120.7}{77.01}$ is greater than $\frac{23.04}{17.12}$

Morbidity Rates. The following formula gives the crude morbidity rate:

$Rm = K\left(\frac{M}{P}\right)$ where

$Rm =$ the crude morbidity rate
$K =$ a constant
$M =$ the number of cases of morbidity (or illness) from a given cause
$P =$ the population of the area where cases of illness exist

The morbidity rate measures the incidence rate of sickness and is also very crude indeed. This rate, however, is of practical value to the administrator of public health for it tells him whether an epidemic exists or not and how much of one. Many of the communicable diseases are reportable in most communities but custom varies widely in this respect. Usually the state health officer at least must be notified of such communicable disease as may be specified by the legislature of that state. At least one or more states require the notification of the following diseases:

COMMUNICABLE DISEASES

Actinomycosis
Anthrax
Chancroid
Chicken pox
Cholera (Asiatic)
Dengue
Diarrhea and enteritis under two years of age
Diphtheria
Dysentery
Erysipelas
Favus
Food poisoning
Foot and mouth disease in man
German measles
Glanders
Gonorrhea
Hookworm
Influenza
Leprosy
Lethargic encephalitis
Malaria

COMMUNICABLE DISEASES—*Continued*

Measles
Meningitis (*Meningococcus*)
Mumps
Ophthalmia neonatorum (conjunctivitis of new born)
Paragonimiasis (infection with the lung fluke)
Paratyphoid fever
Plague
Pneumonia
Poliomyelitis (acute) (infantile paralysis)
Puerperal fever
Rabies
Relapsing fever
Rocky Mountain spotted fever
Scarlet fever
Septic sore throat
Smallpox
Syphilis
Tetanus
Trachoma
Trichinosis
Tuberculosis (all forms)
Tularemia
Typhoid fever
Typhus fever
Undulant fever (Brucellosis)
Whooping cough
Yellow fever

OCCUPATIONAL DISEASES

Anilin poisoning
Arsenic poisoning
Benzine (gasoline) poisoning
Benzol poisoning
Bisulphide of carbon poisoning
Compressed-air illness
Brass poisoning
Carbon monoxide poisoning
Dinitrobenzene poisoning
Lead poisoning
Mercury poisoning
Naphtha poisoning
Natural gas poisoning
Phosphorus poisoning
Turpentine poisoning
Wood alcohol poisoning

DISEASES OF METABOLISM

Beri-beri
Pellagra

ILL-DEFINED OR UNKNOWN CAUSES OF DISEASE

Fever lasting seven days or more
Drug addictions or habits
Cancer

Morbidity rates are very useful to the administrators of institutions such as large boarding schools and colleges in knowing what to expect; in determining the presence or absence of epidemics; and providing adequate medical care for a large group of people. These morbidity rates are the only ones of reliability for the correct estimation of the amount of illness in a given place.

Specific morbidity rates may be obtained for certain age groups, sexes, races, etc., by applying the same general formula as the ones above:

$$Rms = K\left(\frac{Ms}{Ps}\right) \quad \text{where}$$

Rms = specific morbidity rate
K = a constant
Ms = number of cases of a given disease or group of diseases
Ps = the population of the specific group being studied

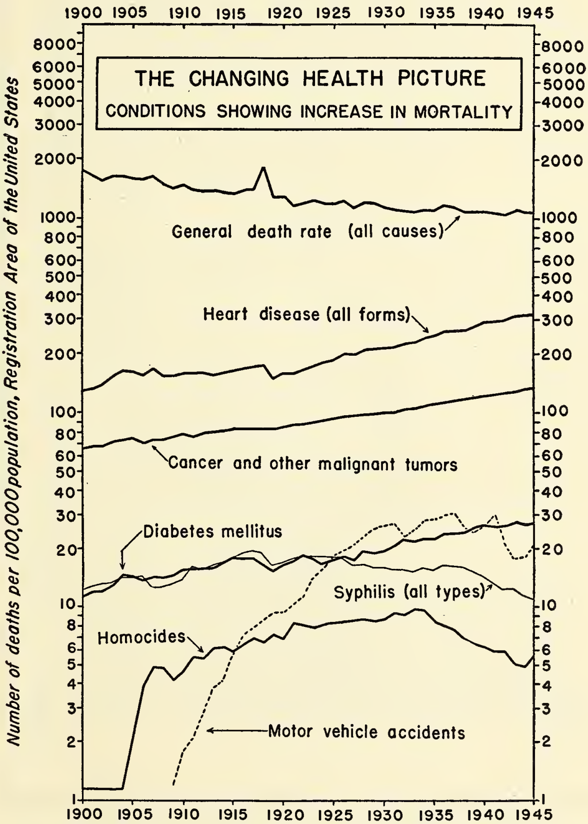

Fig. 109. The data shown on this chart are plotted on a semi-logarithmic scale (arithlog grid) for more accurate comparison of rates.

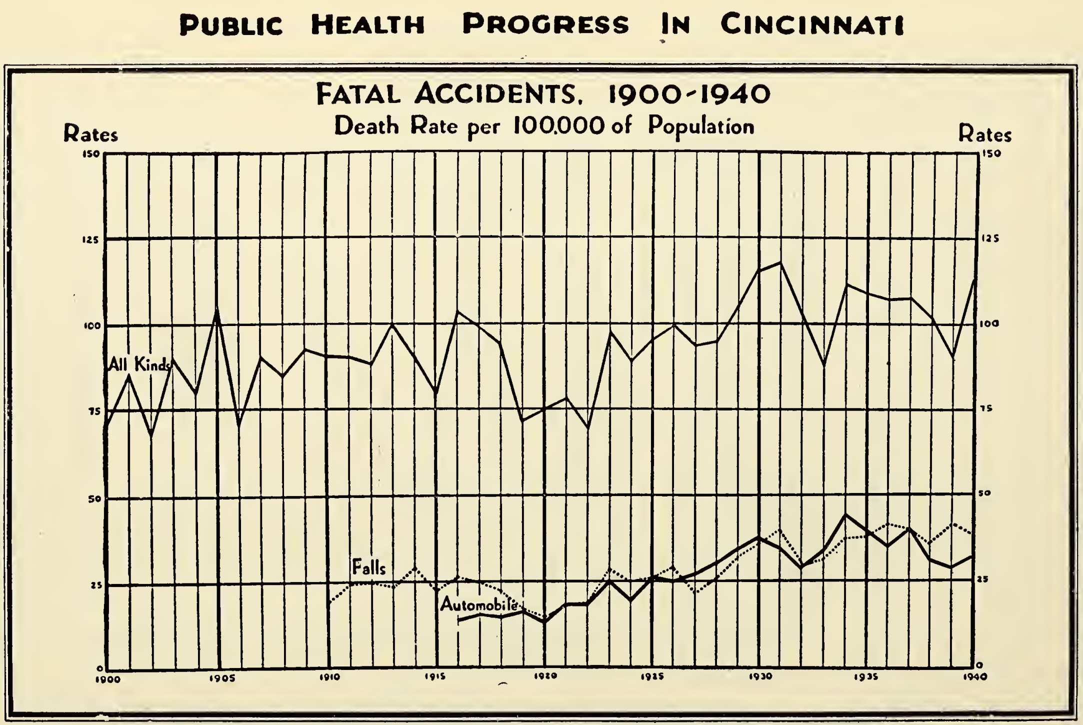

FIG. 110. By an analysis of this chart, plotted on an arithmetic grid, the student may learn (1) that the death rate for fatal accidents in Cincinnati has remained fairly constant, (2) that were it not for the automobile this rate would show a decline from 1916 on, and (3) that by a summation of the curves for fatal accidents caused by falls and the automobile he may judge the rate for miscellaneous fatal accidents. Compare this chart with Fig. 111.

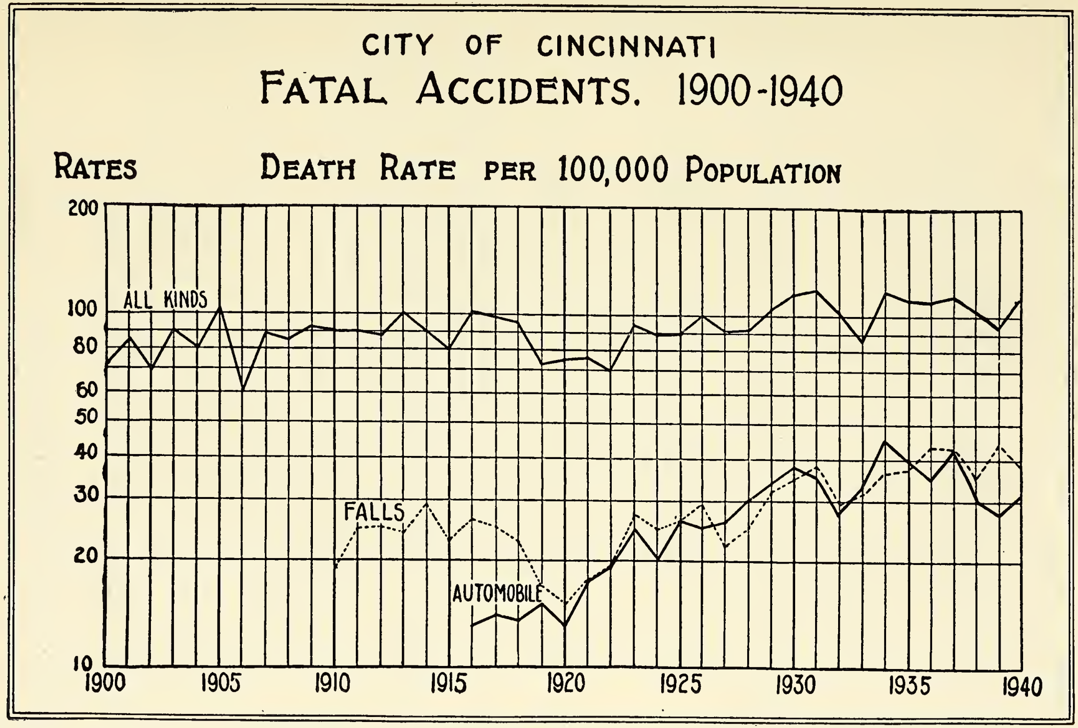

Fig. 111. This chart drawn on the semi-logarithmic scale (arithlog) does not represent the same facts as that in Fig. 110, although the same data were used. The same conclusions as those in Fig. 110 cannot be drawn but additional information is obtained from this chart, viz., that the *rate of increase* of deaths caused by automobiles is greater than that caused by falls or miscellaneous factors.

Death Ratios. A death ratio may be determined by formula:

$$R + D = K\left(\frac{D'}{D}\right) \quad \text{where}$$

$R + D$ = the death ratio
D' = deaths from a particular cause (or group of causes)
D = the total deaths from all causes in the same time interval

The vital index or birth-death ratio may be determined by:

$$\text{Vital index} = \frac{100 \times \text{births}}{\text{deaths}}$$

Using this formula for the vital index we find the trend in the United States as a whole (Registration Area) as follows:

1915	(100 × 776,304)	÷ 436,593	= 177
1920	(100 × 1,508,874)	÷ 836,134	= 180
1925	(100 × 1,878,800)	÷ 1,030,518	= 182
1930	(100 × 2,203,958)	÷ 1,321,367	= 167
1935	(100 × 2,155,105)	÷ 1,392,752	= 157
1940	(100 × 2,360,399)	÷ 1,417,269	= 167
1945	(100 × 2,735,456)	÷ 1,401,719	= 195

This vital index would seem to indicate that the virility of the people of the United States was greater in 1945 than it was in 1915. Raymond Pearl says, "After much study of it, I am convinced that no single figure gives so sensitive a measure of the vitality of a nation or any subgroup of people as this does." If the vital index is greater than one hundred, the population is increasing. If on the other hand it is decreasing, an unhealthy biological state exists.

Practical Application of Vital Statistics: Many people have developed a distrust of vital statistics because they have not always been intelligently handled when presented to the public or unwarranted conclusions have been drawn from the figures. Thurman B. Rice calls attention to the common errors [4] which are as follows:

1. Errors in the original data.
2. Clerical errors in the compilation of same.
3. Errors on the part of statisticians adjudging the value of the data and in determining the form that the statistics made from the original data should take.

[4] A Life and Death Matter." *Hygeia,* December 1928.

4. Misinterpretation of the meaning of the data by those who are using them.
5. Errors in graphic representation of figures (see Figs. 110 and 111).
6. Misquoting the figures when the official record of the same is not at hand.
7. Errors arising rarely from deliberate misrepresentation of known facts but more often from overzealous advocacy of some pet theory or cause.
8. Errors arising from the study of too small a group.

As the author points out a crude death rate is unfavorable in a community which is a medical center, where large numbers of people come for treatment and many die there; or where a large old folks home is situated; or an orphan asylum (the death rate is high in such institutions); or in localities where many older people retire (*e.g.*, in certain sections of Florida and California). A college town, for example, will show a low birth rate, because many students give their permanent address in that town, especially those who are self-supporting.

SELECTED REFERENCES FOR FURTHER STUDY

Pearl, Raymond. *Introduction to Medical Biometry and Statistics.* Philadelphia, W. B. Saunders Co., (3rd edition), 1940.

Rosenau, M. J. *Preventive Medicine and Hygiene,* Section XI. New York, Appleton-Century-Crofts, Inc., (6th edition), 1935.

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18

DIFFICULT HEALTH PROBLEMS

The Changing Health Picture: In recent years the health picture has changed and a few of the changes were mentioned in several places above. Some of the details of present-day health problems will be considered here as they concern community health activities. It is obvious from various charts and tables shown in the preceding chapters that most communicable diseases are on the decline. Modern preventive and curative practices of health workers have caused people to live longer and, in a general way, to enjoy better health. The emphasis of these workers is shifting toward the health problems encountered by middle-aged and elderly people although individuals of all ages are concerned in many of them. If one considers the causes of death as outlined in Table IX these present a definite challenge concerned with the degeneration of man and the persistence of chronic disease. The health worker is concerned with the prevention of all disease not merely communicable disease. The latter has occupied his time and thought for many years because it was so prevalent. Now the emphasis changes and he is confronted with difficult but not always insoluble problems. (See Fig. 109.) The question now is, what can community health activities contribute to the solution of these extensive health problems?

Disease of the Heart: For some years the various forms of heart disease have been the commonest cause of death in the United States. These forms are somewhat different in that their causes are different. A certain number of cases have existed since birth and are called congenital heart disease. Such cases do not comprise a large group as not more than about 0.5 per cent of all babies born show congenital heart conditions. Some such cases are greatly benefitted and a few are practically cured by surgery. The community problem here is to make available to all cases, that may be expected to benefit by it, the advantage of modern surgery, irrespective of the incomes of the parents of such children. For those who cannot benefit by surgery, or are unwill-

ing to assume the risk, specific provisions should be made for handling the child in a special school or in a special class in school where his activity can be carefully supervised. Also transportation should be provided for such handicapped children as activity must be curtailed in practically all cases of this type.

Rheumatic heart disease is the commonest form of heart disease found in the younger person. Damage to the lining and the valves of the heart occurs following an infection called acute rheumatic fever. The exact cause of the rheumatic fever is not definitely known and hence specific preventive measures cannot be applied. At the present time about one childhood death in eight is caused by rheumatic fever in its acute or chronic form.[1] There is a definite familial pattern in its incidence.

It is found more frequently in the slums than in good residential districts. Poverty, unsanitary environment, and low family income play an important though little understood role. It is more common among Negro than white children. Whether this is a true racial difference or not is open to question as the social and economic status of colored people in general is not what it should be. Rheumatic heart disease has a tendency to become aggravated when proper medical treatment is lacking, therefore the community should provide such treatment in those cases where low family income exists.

It has been observed that repeated attacks of sore throat caused by certain hemolytic organisms results in recrudescences of rheumatic fever and further impairment of the heart. The management of such cases is of course the duty of the private physician but drugs required are usually expensive and community aid is often indicated.

Health departments can aid in the search for individuals in the community who have rheumatic heart disease and direct efforts toward getting such cases under medical supervision. Toward this end acute rheumatic fever and rheumatic heart disease is made reportable in some cities and health districts. Public health nurses are often assigned the follow-up work in an effort to improve the status of the individual. The health department often maintains a cardiac clinic for the treatment of those unable to pay a private physician. Convalescent homes and sanatoria are of great value in this connection. Inasmuch

[1] Wilson, M. G. *Rheumatic Fever*. New York, The Commonwealth Fund, 1940.

as cold weather has an adverse effect upon rheumatic fever these convalescent homes should be located in warm climates.

As with congenital heart diseases, special provision should be made for the transportation and education of the rheumatic heart case. This is certainly the duty of the community. Control of the individual and his activities by school health examinations and recommedations is important and is a well-recognized function of the health activities of the school.

Syphilitic heart disease cannot be improved after it has developed in the individual. At this point the damage has been done and neglect was the real cause of the tragedy. The defect usually appears in the fifth decade of life and after the individual has had syphilis for a number of years. Syphilitic heart disease can be prevented by adequate modern treatment of the disease in its early stages. The earlier the treatment is begun the better for the individual and case finding of syphilis in the community becomes an important activity. Free treatment for those unable to pay should be provided. The drugs used in the treatment of syphilis are expensive and should be furnished by the community for those able to pay something for their treatment but unable to pay the whole amount. (This is done in many states.) Preventive measures effective against syphilis were discussed in Chapter 5.

Other infectious diseases such as scarlet fever, tonsillitis, and gonorrhea, sometimes cause valvular heart disease. Formerly diphtheria was a common cause of myocarditis. The prevention of diphtheria and its early and adequate treatment has greatly reduced the number of such cases.

Heart disease secondary to high blood pressure is a complicated medical problem. Periodic examinations will reveal the condition early and the individual can do much toward living within the limits of his capacity for activity. As obesity is often a contributing factor the medical treatment of this conditions should be provided.

Such factors as worry, fatigue, overstrain, and bad habits concerned with anger, fear, psychological distress, and other evidences of bad mental hyigene, which have a deleterious effect upon the individual, can often be helped by the psychiatrist or the personnel in mental hygiene clinics maintained by a health department or other community organization.

Coronary artery occlusion is the most prominent form heart disease

assumes in middle-age. It seems to be on the increase. When the typical sudden attack developed, some years ago, it was almost invariably called acute indigestion. Coronary occulsion, often caused by the formation of a blood clot in a coronary artery and called coronary thrombosis, results in the sudden stoppage of blood supply to the heart itself. Just what causes this clot formation is not known although high blood pressure, obesity, overeating, excessive use of tobacco, stress or strain of business or professional activities, and lack of rest and relaxation are believed to play important roles in its development. Education is important in the avoidance of this condition and improved medical treatment has done much to prevent repeated attacks in coronary thrombosis. The community can do much toward the education of people in sane living and can supply expert medical care for those who cannot afford to pay for it.

A variety of other causes of heart disease such as toxic goiter, pellagra, and chronic alcoholism, have definite preventable aspects and are the concern of community health workers.

General Measures in the Control of Heart Disease: The public has a lack of understanding of the causes of heart disease. Health education could do a great deal of good here. Because heart disease is usually disabling and its treatment expensive, the problems concerned in its management are often financial. In all probability its increase will not be checked until the problem is attacked with this idea in mind. Anyone with heart disease deserves adequate medical care. This requires expensive equipment for the private physician and expensive drugs for the patient. It also requires expert professional management usually beyond the means of most people with heart disease. If such is the case the community should provide the necessary services. The public health nurse is of great help when the cases are treated at home. The establishment of simple nursing homes for cardiac cases is essential in many instances. If the family cannot pay for such care then the community should provide it. It has been suggested that as tuberculosis recedes, and public sanatoria originally built for the treatment of this disease are no longer needed, they be converted to the use of cardiac patients.[2] Adequate hospital treatment for those cases requiring expert care by a cardiologist should be available.

[2] Smillie, W. G. *Preventive Medicine and Public Health,* p. 439. New York, The Macmillan Co., 1946.

Cancer: The second commonest cause of death is cancer. The community responsibilities concerned with this disease are several. Inasmuch as its cause is unknown, scientific research should be subsidized to the limit. Any capable scientist with a promising idea, or with the necessary skill to follow through an investigation should be supported thoroughly with everything he needs. The community should establish clinics for the early detection of cancer for those who cannot afford private medical care and make adequate provisions for the treatment of the cases as soon as they are discovered. Education in cancer control has done a great deal of good. An unofficial story is told concerning a recent request made of Congress for funds for cancer research. Expecting the request to be cut in half the federal agency requesting the money asked for double what it hoped to receive. Members of the committee to which the request was referred realized that they themselves were in the age group in which cancer was common and promptly doubled the appropriation asked for. Thus education in cancer prevention did much good in getting funds for research.

Hypertension, Apoplexy, and Nephritis: These three conditions have definite medical relationships. They are strictly medical problems but they have their financial aspects also. In their control the public often needs assistance from community clinics, hospitals, and specialists. In many places such assistance is not available. Much could be done to reduce the death rate or prevent its increase in these conditions were expert medical service at hand.

Diabetes Mellitus: Community health activities often include those concerned with this disease because it is prominent in mortality statistics. Much can be done toward preventing the disease by education directed toward the dietetic habits of people. Obesity is believed to be an important predisposing factor therefore efforts directed toward the prevention of this condition will prevent a certain amount of diabetes. The treatment of diabetes is a medical and financial problem. It usually consists in the patient following a certain diet, receiving insulin daily, and having repeated laboratory tests made especially on the blood sugar. Insulin is expensive and so are the laboratory tests. In such cases these should be provided by the community. The death rate from diabetes should be lower than it is. The chances for the individual's survival when the disease is properly controlled are good.

The community needs better distribution of medical care in this condition as well as in many others.

Alcoholism: Fruits, vegetables, cereal grains, and even the milk of animals have been subjected to fermentation to produce alcohol. This fermentation is accomplished by the use of yeast or bacteria which may be present in the natural food or be added to it. The various popular alcoholic beverages are of two general classes: undistilled beers and wines, and distilled spirits. Wines are obtained from various species of grapes, beer from barley and other grains, rum from molasses, brandy from grapes, apricots, and peaches, gin from rye (sometimes potatoes) flavored with juniper berries, Bourbon whiskey from corn, Irish whiskey from potatoes, Scotch whiskey from barley, and liqueurs and cordials from varied sources. Most beverages are "fortified" to bring up their alcoholic content. Distilled liquors are spoken of as "100 proof" when the alcoholic content is 50 per cent. The proof is double the percentage of alcohol.

The annual per capita consumption of alcohol remains fairly constant in the United States. It is about 5 quarts per year or the equivalent of about 10 quarts of 100 proof whiskey or other distilled spirit.[3] Alcohol addiction is common throughout western civilization and the per capita consumption of alcohol in European countries is high. The problem of inebriety is of prime importance in any community and leads to accident causation, ill health, and premature death. Because the alcoholic addict can obtain a large number of calories from the liquor he drinks he has no desire for food as a rule. This leads to dietary deficiency diseases among such people.

In the excessive use of alcohol there is no physiological mechanism for protection against an overdose. Its poisonous effects are characterized by the abolition of functions of the brain with a resultant characteristic stupor. There is an inhibition of the respiratory function and very large doses result in asphyxiation by paralysis of the respiratory center as is the case in opium and morphine poisoning. A 0.6 per cent concentration of alcohol in the blood may be sufficient to cause death from respiratory and cardiac failure. More than 0.12 per cent of alcohol in the blood will usually result in intoxication.

In chronic alcoholism organic changes often take place such as im-

[3] Jellinek, E. M. et al. *Alcohol and Chronic Alcoholism*. New Haven, Yale University Press, 1942.

pairment of nerve function, liver damage, dietary deficiency diseases, mental diseases, and sometimes blindness. The chronic alcoholic is almost always a psychiatric problem. Alcoholism is more the symptom of a psychosis than the cause of mental disease. Most observers notice a strong paranoid tendency in those who drink to excess. However, there is no definite personality pattern in these patients as they are not a homogeneous group.

Among the more serious effects of inebriety are the psychoses which the addict develops. These mental diseases are serious, disabling, and may even be fatal. The community should provide adequate medical care for the rehabilitation of their chronic alcoholics. This would probably save money in the long run becase very few heavy drinkers can hold a position in business or a profession. They cannot support their families which often become public charges. It would probably cost less to rehabilitate the individual if that were possible. Many cases of chronic alcoholism can be cured by proper psychiatric treatment.

Distribution of Medical Care: It is obvious that the major health problems of the moment are concerned with a certain lack in the distribution of medical care and insufficient public health activity. (See Fig. 12.) They are the subject of violent disputes among certain groups. The facts are quite clear when one studies the various aspects of the question.

In 1905 there were 160 medical colleges graduating 5,606 students with the degree of doctor of medicine. In 1948 there were 77 medical colleges graduating 5,543 individuals with this degree. Thus there were fewer physicians graduated in 1948 than there were in 1905. It is quite true that many of the 160 colleges in 1905 were not much better than diploma mills which provided poor instruction and graduated many physicians not properly trained or educated. The American Medical Association put into effect vigorous inspection and classified these schools. State legislatures were persuaded to refuse licenses to practice medicine to those graduating from the colleges which were not classed "A" by the association. This was an honest activity and intended to benefit the public. The result was a tremendous improvement in the practice of medicine in the United States, but there were not enough physicians trained each year to provide medical care for the people. The population of this country in the census year 1900

was 75,994,575 and in the year 1940 was 131,669,275. In the 43 years between 1905 and 1948 the population had almost doubled while the number of medical graduates had remained about the same year after year. At the present time the number of medical graduates is hardly sufficient to replace the physicians who die or retire each year and the population is constantly increasing. From the standpoint of community and individual health an alarming situation exists. There are 17 states where either laws prohibit the dissection of the human body or animal experimentation or where the state does not appropriate funds to support a medical college.

It is a well-known fact that several times as many qualified students apply to the 77 medical colleges of this country as these places are able to accept. The solution of the problem is so simple that it need not be discussed.

Conclusion: That health problems of great magnitude exist is obvious to the well-informed person. Many of these problems were outlined above but there was not room to include them all. That mankind realizes that health problems capable of solution do exist is a hopeful sign. Continuous and unrelenting effort is needed in the solution of these problems by those people who, by their very nature, are crusaders. There is no more worthy field of endeavor than the prevention of disease and the promotion of health.

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GLOSSARY

NOTE.—Most technical words are defined in the text of the book preceding this glossary, and the student is advised to consult the index first for reference to these definitions. The following definitions are not necessarily complete and exact, but are somewhat simpler than those given in the medical dictionary. The student is urged to acquaint himself with the more scientific definitions to be found in the unabridged dictionary or the medical dictionary. For one who is a linguist the language from which the term is derived is indicated by the following symbols: *Ar.*—Arabic; *Fr.*—French; *Gr.*—Greek; *Ital.*—Italian; *L.*—Latin; *Sp.*—Spanish; etc.

ABORTION (*L.*). The termination of a pregnancy before the sixteenth week (see Miscarriage).

ADENITIS (*Gr.*). Inflammation of a gland.

ADENOIDS (*L.*). Mass of gland-like tissue in the back part of the nose which usually causes some obstruction to breathing through the nose.

ALLERGIC SUBSTANCES (*Gr.*). An inclusive term used to describe all material which will cause an unusual or exaggerated reaction in a sensitive individual.

ALVINE (*L.*). Pertaining to the intestines.

AMEBIC DYSENTERY (*L.*). Dysentery caused by a protozoön (see Dysentery).

AMMONIA (*L.*). A colorless alkaline gas, NH_3, of penetrating odor and soluble in water.

AMYL ALCOHOL (*Gr.* and *Ar.*). $C_5H_{11}OH$, obtained from corn whiskey and potato whiskey. It is poisonous.

ANAËRORIC (*Gr.*). Thriving best without air.

ANAPHYLAXIS (*Gr.*). The state of unusual or exaggerated susceptibility to a foreign protein which sometimes follows a primary injection of such protein. For example if a child receives horse serum once he is apt to react unfavorably to a second dose of the same kind of serum.

ANEMIA (*Gr.*). A condition in which the blood is deficient either in quantity or quality. A deficiency of iron in the blood.

ANESTHESIA (*Gr.*). Loss of feeling or sensation, especially the loss of the sense of touch. It is induced by the injection or inhalation of certain chemicals. It occurs as the result of certain diseases.

ANNEXA (*L.*). Adjunct parts.

ANTIBIOTIC (*Gr.*). A substance used for the treatment of certain infections; it is extracted from molds, bacteria, or other forms of life.

ANTIBODIES (*Gr.*). Specific substances which resist diseases or which cause a

reaction to foreign substances. They are produced as a response to the injection of a substance (antigen) or in recovery from an acute disease.

ANTITOXIN (*Gr.*). Any defensive protein, either existing normally or developed in the body as a result of the implantation of a poison and acting as a neutralizer of the poison.

APPENDICITIS (*L.*). Inflammation of the vermiform appendix, a worm-like appendage to the lower bowel.

ARNOLD STERILIZER. A device used to sterilize with actively streaming steam.

ARSENIC (*L.*). A nonmetallic, brittle, lustrous, gray solid with a garlic-like odor. Its compounds are used for the treatment of a number of diseases including syphilis.

ARTERIES (*L.* and *Gr.*). Vessels through which the blood passes from the heart to the various parts of the body. (Arteries were thought by the ancients to contain air).

ARTERIOSCLEROSIS (*Gr.*). Hardening of the arteries.

ARTHRITIS (*Gr.*). Inflammation of a joint.

ASCORBIC ACID (*L.*). See Vitamin C.

ASEPSIS (*Gr.*). Absence of septic matter, or freedom from infection.

ASSIMILATION (*L.*). The transformation of food into living matter, or into energy.

ASTHMA (*Gr.*). Literally "panting." A disease characterized by periods of difficult breathing; inspiration is usually short in duration but expiration is prolonged and difficult.

ATABRINE. A proprietary drug of complex structure derived from acridine and used in the treatment of malaria.

AUREOMYCIN (*Gr.*). An antibiotic substance derived from *Streptomyces aureofaciens,* a fungus.

AUTOCLAVE (*Gr.* and *L.*). An apparatus for effecting sterilization by steam under pressure.

AUTOPSY (*Gr.*). The postmortem examination of a body; the examination of a body after death.

B. An abbreviation for *Bacillus.*

BACITRACIN (*L.*). An antibiotic substance derived from cultures of *Bacillus subtilis* found in hay.

BCG. An abbreviation for *Bacillus Calmette Guérin,* a substance used for vaccination against tuberculosis. It consists of living cultures of bovine tuberculosis organisms which have grown over a period of years in glycerinated ox bile until their virulence has been greatly reduced.

BENZOATE OF SODA (*L.*). The sodium salt of benzoic acid.

BENZOIC ACID (*L.*). A white, crystalline acid, $C_7H_6O_2$, from benzoin and other resins and from coal-tar.

BERKEFELD FILTER. A filter made of diatomaceous earth (Fuller's earth) or earth composed of the skeletons of minute animals.

BISMUTH (*L.*). A silver white metal element usually found in the form of a salt and used for the treatment of several diseases including syphilis.

Botulism (*L.*). A type of food poisoning caused by the growth of *Clostridium botulinum* in improperly canned or preserved foods.

Bovine (*L.*). Pertaining to or derived from the steer, bull, ox, cow, or heifer.

Bronchi (*Gr.* and *L.*). Tubes leading from the throat or windpipe into the lungs.

Bronchitis. Inflammation of the bronchi.

Cancer (*L.*). A malignant tumor or growth which tends to spread within the human body.

Carbohydrates (*L.*). Compounds made up of carbon, hydrogen and oxygen in the proportion to form water, *e. g.*, glucose, $C_6H_{12}O_6$.

Carbon Dioxide (*L.*). Carbonic acid gas, CO_2, forming with water carbonic acid. It is obtained by the burning of carbon with free access of oxygen. When breathed nearly pure it causes death by suffocation.

Cellular Tissue. Tissue composed of cells; usually the loose tissue found just under the skin.

Cerebral Hemorrhage (*Gr.*). Apoplexy or "stroke."

Cervical (*L.*). Pertaining to the neck.

Chancroid (*Fr.*). A soft non-syphilitic venereal sore.

Chemotherapy (*Gr.*). Treatment with chemical substances which have a special ability to improve the natural resistance of the body or have a neutralizing or destructive effect on microorganisms.

Chickenpox. An acute contagious disease of children characterized by fever and an eruption.

Chloromycetin (*Gr.*). An antibiotic substance derived from several species of *Streptomyces,* a fungus.

Cholera Morbus (*Gr.* and *L.*). Acute gastro-enteritis, with diarrhea, cramps and vomiting, usually occurring in summer or autumn, and called "Summer Complaint."

Circulatory System. The heart, blood, and lymphatic vessels, the blood and lymph.

Communicable (*L.*). Readily transferred from one person to another, *e.g.,* communicable disease; contagious.

Complement (*L.*). A ferment-like body in the blood serum of animals and man. In complement-fixation tests, such as the Wassermann test for syphilis, the active element in causing hemolysis of certain animal cells is the complement in the blood serum of the person being tested.

Conception (*L.*). The fertilization of the ovum by the spermatazoön.

Confinement (*Fr.*). Pregnancy or the confinement to home or bed as a result of pregnancy.

Congenital Malformations (*L.*). Deformities existing before birth.

Conjunctivitis (*L.*). Inflammation of the membrane that lines the eyelids and covers the eyeball.

Contagious. See Communicable.

Convalescence (*L.*). The period of recovery following an attack of disease.

Count (Bacterial). The number of bacteria per unit of volume.

Cowpox. See Vaccinia.

Croup (*Scot.*). A disease characterized by laborious and suffocative breathing.

Debridement (*Fr.*). Surgical removal of dead tissue from a wound.

Delirium (*L.*). Literally "off the track" (*de lira*). An abnormal mental state with hallucinations, delusions, excitement, excessive activity and caused by infections, toxic substances, or head injuries.

Diabetes (*Gr.*). A disease characterized by excessive excretion of urine. When used as a single word it usually refers to diabetes mellitus, a disease characterized by the inability to store and burn sugar in the body.

Diarrhea (*Gr.*). Frequent and watery bowel movements.

Diphtheria (*Gr.*). An acute infectious disease characterized by patches of false membrane formed chiefly on the mucous membrane of the throat. Swelling of the larynx and pharynx is also present.

Disorientation (*L.*). The loss of proper bearings; a state of mental confusion as to time, place, or identity.

Dysentry (*L.*). A specific febrile disease marked by nervous prostration and marked inflammation of the large intestine and lower small intestine.

Dysmenorrhea (*Gr.*). Painful and difficult menstruation.

Edema (*Gr.*). Swelling in tissues.

Effluent (*L.*). Material flowing out of a container.

Embryo (*Gr.*). An immature animal, or the early stage of an animal (see Fetus).

Encephalitis (*Gr.*). Inflammation of the brain. Encephalitis lethargica is a disease of obscure symptoms the more distinctive features being an increasing languor, apathy, and drowsiness passing into lethargy. This is an inexact term and should not be used; "epidemic encephalitis" is better.

Encysted (*Gr.*). Enclosed in a sac or bladder-like structure.

Enteritis (*Gr.*). Inflammation of the intestine.

Enzyme (*Gr.*). A chemical ferment formed within the body.

Eruption (*L.*). A breaking out on the skin.

Erysipelas (*Gr.*). An acute, febrile, somewhat contagious disease marked by intense local redness of the skin and mucous membranes.

Excreta (*L.*). Waste materials cast out by the body.

Febrile (*L.*). Pertaining to or having a fever, or increased body temperature; feverish.

Federally Inspected Meat. Meat examined and passed or rejected by inspectors employed by the United States Government.

Ferment (*L.*). An agent which causes decomposition of a complex molecule of organic material.

Fetus (*L.*). The unborn child after the third month of pregnancy. Before that time it is called the embryo (human).

Filtrable (*L.*). Capable of passing through a filter, usually a Berkefeld filter.

Filtrate (*L.*). The fluid which goes through a filter.

FORMALDEHYDE (*L.* and *Ar.*). A gaseous compound with a pungent odor used as a disinfectant, HCHO.

FORMALIN. A water solution of formaldehyde.

FUNCTIONAL (*L.*). Affecting the functions but not the structure of an organ.

FUNGUS (*L.*). A spongy mass of vegetable organisms of a low order of development including molds, mushrooms, etc.

GALL-BLADDER. A pear-shaped reservoir for bile found on the under side of the liver.

GAS BACILLUS. Same as *Clostridium welchi.* A facultative bacillus ordinarily passing a saprophytic existence in the soil, and possessing the ability to produce large quantities of gas in the human tissues when it becomes pathogenic.

GASTROENTERITIS (*Gr.*). An inflammation of the stomach and intestines with symptoms similar to enteritis and dysentery.

GASTRO-INTESTINAL DISORDERS (*Gr.*). Abnormalities of the stomach and intestines or bowels.

GENITO-URINARY SYSTEM. Reproductive and urinary organs.

GLAND (*L.*). An organ which separates any fluid from the blood; a secreting organ, *e.g.,* a sweat gland.

GLOBULIN (*L.*). A protein of the blood of animals and man which carries immune substances, especially antitoxin.

GOITRE OR GOITER (*Fr.*). Enlargement of the thyroid gland; a swelling in the lower front neck.

GONORRHEA (*Gr.*). A contagious catarrhal inflammation of the genital organs and sometimes of the eye, characterized by discharge of mucus and pus.

GRAMICIDIN (Named after the Danish bacteriologist Hans Christian Gram.) A purification product of tyrothricin (which see).

GRIPPE (*Fr.*). Influenza.

GROIN (*L.*). The lowest part of the abdominal wall near its junction with the thigh.

GYNECOLOGY (*Gr.*). That branch of medicine and surgery which treats of women's diseases, especially of the sex organs, bladder, or kidneys.

HAY FEVER. A disease characterized by an acute nasal discharge and caused by the patient's susceptibility to dust, pollen, chemicals, and many other substances.

HECHT-GRADWOHL TEST. A modification of the Wassermann test for syphiils.

HEMORRHOIDS (*Gr.*). Vascular tumors of the rectal mucous membrane (containing blood); piles.

HEMOLYTIC (*Gr.*). Causing dissolution of red blood cells and liberation of hemoglobin in the blood streams.

HEPATITIS (*Gr.*). Inflammation of the liver.

HERMETICALLY (*L.*). In an air-tight manner.

HERNIA (*L.*). The protrusion of a loop or knuckle of an organ or tissue through an abnormal opening (Celsus). Popularly called a "rupture."

H-H Inhalator. A device used in artificial respiration to give oxygen from a tank to a person who is suffocated.

Hippuric Acid (*Gr.*). A crystallizable acid, $C_9H_9O_3$, from the urine of domestic animals especially horses; sometimes found in human urine.

Histoplasmosis (*Gr.*). A disease caused by *Histoplasma capsulatum,* a fungus. It is usually mild and symptomless. It causes confusion in reading X-ray films of the chest because it produces calcification of the lung tissue very much like tuberculosis does.

Hypertension (*Gr.* and *L.*). High blood pressure.

Hypodermically (*Gr.*). Under the skin.

Hysteria (*Gr.*). A disease characterized by lack of control over acts and emotions and by marked self-consciousness.

Idiocy (*Gr.*). Complete congenital feeblemindness; lack of any mentality or understanding.

Imbecility (*L.*). Feeblemindedness either congenital or acquired; mentality of a higher grade than idiocy but not as high as moronity.

Immune Serum. A serum containing one or more antibodies for protection against or treatment of disease.

Immunity (*L.*). The power which any living organism possesses to resist and overcome infection.

Immunization (*L.*). Rendering the individual immune; vaccination.

Impetigo (*L.*). An infectious skin disease characterized by pustules and scabs.

Infectious (*L.*). Caused by bacteria, protozoa, or filtrable viruses.

Insanity (*L.*). A marked disorder of the mental faculties.

Interstitial Keratitis (*Gr.*). Chronic inflammation of the eye with deep deposits in the substance of the cornea which becomes hazy throughout and has a ground-glass appearance. The disease is associated with syphilis and occurs in children before the fifteenth year.

Intracranial Lesions. Marked alteration of tissue within the skull.

In Utero (*L.*). Within the uterus or womb.

Kahn Test. A simplified test for syphilis which depends upon precipitation for a positive reading.

Kolmer Test. A modification of the Wassermann test for syphilis.

Labia Majora (*L.*). The hairy folds of skin on either side of the vulva, and closing the vagina.

Labia Minora (*L.*). The folds of mucous membrane within or between the labia majora.

Labor (*L.*). Childbirth.

Larva (*L.*). The first stage in the development of an insect.

Laryngitis (*Gr.*). Inflammation of the larynx or voice box (usually characterized by a loss of voice).

Lymphadentis (*L.* and *Gr.*). Inflammation of the lymph glands (often caused by tuberculosis or syphilis).

Malaise (*Fr.*). Uneasiness, indisposition, discomfort, or distress.

Malnutrition (*L.*). Imperfect assimilation of food.

MASTOID (*Gr.*). When used as a single word the term applies to the bone behind the ear containing air cells, and connected with the middle ear.

MEASLES (*L.*). A contagious disease characterized by fever, watery eyes, and a skin rash.

MENINGITIS (*Gr.*). Infection of the coverings of the brain.

MENSTRUATION (*L.*). The monthly sanguineous discharge of women.

METABOLISM (*Gr.*). The sum of all the physical and chemical processes by which living organic substance is produced and maintained; often called "metabolic process."

METAZOIC TEMPERATURE (*Gr.*). The body temperature of animals; this varies with each species of animal.

METHANE. Marsh gas, CH_4 a colorless, odorless, inflammable gas produced by the decomposition of organic matter.

MIASM (*Gr.*). A noxious effluvium or exhalation.

MICRO-ORGANISM (*Gr.*). Any minute animal or plant so small as to require a microscope to be seen.

MILK SICKNESS. See Trembles.

MISCARRIAGE. Birth of the fetus before the twenty-eighth week and after the sixteenth week.

MONONUCLEOSIS, INFECTIOUS. A disease characterized by an enlargement of the lymphatic glands and an increase in the number of lymph cells in the blood.

MORBIDITY (*L.*). The sick rate or proportion of disease to health in a community.

MORONITY (*Gr.*). Relating to defectives who have never advanced beyond the mental stage of a twelve-year-old child.

MORTALITY (*L.*). The death rate.

MUCOCUTANEOUS (*L.*). Pertaining to the mucous membrane and the skin.

MUCOUS MEMBRANE (*L.*). Abbreviation mm. A membrane secreting mucus and lining the cavities of the body which connect with the outside air, such as the respiratory, genito-urniary and digestive tracts.

MUCUS (*L.*). A viscid, watery secretion of the mucous glands.

NAUSEA (*L.,* also *Gr.*). Sickness at the stomach with a tendency to vomit.

NEOMYCIN (*Gr.*). An antibiotic derived from *Streptomyces fradiae,* a fungus.

NEPHRITIS (*Gr.*). Inflammation of the kidney.

NERVOUS (*L.*). Pertaining to the nerves or the fibers and cells in the body which conduct impulses.

NEURALGIA (*Gr.*). Pain in a nerve.

NEURASTHENIA (*Gr.*). Nervous prostration; severe emotional weakness.

NICOTINIC ACID. Also called niacin. An accessory food substance which prevents pellagra.

NITRATES (*L.*). Any salt of nitric acid.

NON-VENEREAL (*L.*). Not contracted in sexual intercourse.

NUTRITION (*L.*). Process of assimilating food.

OBSTETRICS (*L.*). That branch of surgery dealing with pregnancy and labor.

ORTHOPEDIST (*Gr.*). A surgeon who corrects deformities, especially of children.

OTITIS MEDIA (*Gr.*). Inflammation of the middle ear.

OXIDIZING BACTERIA (*Gr.*). Bacteria which cause a union of the matter in which they are living with the oxygen of the air.

PARESIS (*Gr.*). General paralysis.

PASTEURIZE (*Fr.*). To check fermentation by heating.

PATHOGENIC (*Gr.*). Giving origin to disease; pathological.

PEDIATRICIAN (*Gr.*). A specialist in the treatment of children's diseases.

PENICILLIN (*Gr.*). An extract of green mold or fungus *Penicillium notatum* used as an antibiotic in treating certain infections.

PERITONEAL CAVITY (*L.,* also *Gr.*). The cavity lined with peritoneum.

PERITONEUM (*Gr.*). The serous membrane which lines the abdominal walls and invests the contained organs.

PHARYNX (*Gr.*). The musculomembranous sac between the mouth, nose, and esophagus.

PHRENICOTOMY (*L.,* also *Gr.*). Surgical division of the phrenic nerve for the purpose of causing paralysis of the diaphragm which then becomes pushed up by the viscera so as to compress a diseased lung.

PHYSICAL DIAGNOSIS (*Gr.*). Determination of disease by inspection (seeing), palpation (feeling), percussion (tapping with the finger or instrument), and auscultation (listening).

PLASMOQUINE. A proprietary synthetic compound of quinoline used in the treatment of malaria. It is especially effective against the sexual forms of the parasite.

PNEUMONIA (*Gr.*). Inflammation of the lungs.

PNEUMOTHORAX (*Gr.*). An accumulation of air or gas in the pleural cavity which causes a collapse of the lung. Artificial pneumothorax is the result of pumping air or a gas into the pleural cavity to collapse a lung diseased with tuberculosis.

POLIOMYELITIS (*Gr.*). Inflammation of the gray substance of the spinal cord, resulting in paralysis. (Same as Infantile Paralysis).

POLLEN (*L.*). Minute male fertilizing elements in flowering plants which float in the air.

POST-MORTEM (*L.*). After death (see Autopsy).

PPD. Abbreviation for purified protein derivative of tuberculin. A substance used for the tuberculin test in man.

PREGNANCY (*L.*). The condition of being with child.

PREMATURE BIRTH (*L.*). A birth occurring before the normal time, and after the twenty-eighth week of gestation or pregnancy (see Miscarriage).

PRENATAL (*L.*). Existing or occurring before birth.

PREVENTORIUM. An institution similar to a sanatorium where children or adults likely to contract tuberculosis are sent.

PROPHYLAXIS (*Gr.*). The prevention of disease by preventive treatment.

PROTEIN (*Gr.*). A group of complex substances containing carbon, hydrogen,

oxygen, and nitrogen found in animal and vegetable tissue and consisting of the alpha-amino-acids.

PSYCHIATRIST (*Gr.*). An expert in the treatment of mental disorders.

PSYCHONEUROSIS (*Gr.*). Any nervous disorder affecting the mind or of mental origin, less severe as a rule than a psychosis.

PSYCHOSIS (*Gr.*). A disorder of the mind characterized by mental aberration.

PUERPERAL (*L.*). Pertaining to childbirth.

PULICIDE (*L.*). Anything which will kill fleas.

PULMONARY (*L.*). Of the lungs.

PUPA (*L.*). Literally a "doll." The second stage in the development of an insect.

PUPARIUM (*L.*). The pupal case.

PURULENT (*L.*). Consisting of or containing pus.

PUTREFACTION (*L.*). The decomposition of animal and vegetable matter produced by minute organisms.

RECRUDESCENCE (*L.*). The recurrence of symptoms after a temporary abatement. Similar to a replapse but of shorter duration.

RELAPSING FEVER. A contagious bacterial fever often associated with poverty and famine, and believed to be carried by bedbugs.

REMISSION (*L.*). The abatement of the symptoms of a disease.

RESPIRATORY (*L.*). Pertaining to breathing.

RHEUMATIC FEVER (*L.,* and *Gr.*). A constitutional disease marked by inflammation of the connective tissue structures of the body especially in the muscles and joints.

RIBOFLAVIN (*L.*). An accessory food substance which promotes growth and prevents certain symptoms of food deficiency (sore tongue, sore lips). It is found in a wide variety of foods especially liver, eggs, and meat.

ROCKY MOUNTAIN SPOTTED FEVER. A disease characterized by high fever, red spotted eruption and mental derangement.

RODENTS (*L.*). Gnawing mammals with very sharp incisor teeth.

SANITATION (*L.*). The establishment of conditions favorable to health.

SCARLET FEVER (*L.*). An acute contagious fever with a scarlet rash.

SECONDARY CARRIER. Usually an inanimate object which carries disease germs, *e.g.,* water, food, milk, etc.

SEPTIC (*L.,* also *Gr.*). Undergoing decay. A septic tank is one in which sewage is held until it decomposes beyond the ordinary stage.

SEPTICEMIA (*Gr.*). The marked condition due to the presence of pathogenic bacteria and their associated poisons in the blood.

SEPTIC SORE THROAT (*L.,* also *Gr.*). A sore throat produced by or due to putrefaction (a misnomer).

SINUSITIS (*L.*). Inflammation of a sinus or cavity usually near the face or nose.

SLUDGE. A muddy or slimy deposit from sewage.

SPONTANEOUS GENERATION (*L.*). The false theory that living organisms arise from non-living material.

Stereoscopic X-ray Films. Films made so that when viewed in a stereoscope three dimensions may be perceived.

Sterilize (*L.*). To free from septic germs (see Autoclave).

Stethoscope (*Gr.*). An instrument for hearing the various sounds in the body.

Streptomycin (*Gr.*). A substance used in the treatment of tuberculosis, tularemia, and other diseases. It is derived from the fungus *Streptomyces griseus.*

Sulfonamide Drugs. A group of compounds with one or more benzene rings and amino groups; they are used to treat infectious diseases.

Sulphuretted Hydrogen (*L.*). A malodorous gas, H_2S.

Sulphurous Acid. A dibasic acid, H_2SO_3, produced by combining sulphur dioxide, a gas, with water.

Summer Complaint. See Cholera Morbus.

Surgical Tuberculosis (*L.*). Tuberculosis of the bones, joints, or other parts which may be treated by surgical means.

Thiamin (*L.*). See Vitamin B_1.

Thoracoplasty (*Gr.*). Operative or surgical treatment of defects of the chest, especially tuberculosis. (The chest is made smaller and the lung excursion less in breathing).

Thyroid (*Gr.*). A large ductless gland in the front part of the neck (see Goitre).

Tonsil (*L.*). A small almond-shaped mass in the back part of the mouth.

Tonsillitis (*L.*). Inflammation of a tonsil.

Toxin (*Gr.*). A poisonous substance formed by certain bacteria or other agents of infection.

Toxoid (*Gr.*). The product of a toxin no longer toxic but capable of creating resistance to a toxin when injected into an individual.

Tracheobronchial Lymph Nodes (*Gr.*). Lymph glands surrounding the lower trachea and bronchi.

Trachoma (*Gr.*). Contagious granular inflammation of the eyelids and eyeball.

Trembles. A disease of cattle and sheep in which the animal becomes weak and easily tired; it is apt to stumble and fall. (Same as Milk sickness).

Trench Fever (*L.*). A germ disease with a relapsing fever in which the infection is transmitted by the body louse.

Tubercle (*L.*). A nodule or small eminence.

Tubercle Bacillus. *Mycobacterium tuberculosis.* A pathogenic micro-organism causing the disease tuberculosis; it grows in the form of non-motile rods, often somewhat curved.

Tuberculosis (*L.*). An infectious disease characterized by the formation of tubercles in the tissues. A disease of marked complexity and variability of symptoms.

Tyrothricin (*Gr.*). An antibiotic substance obtained from a soil bacterium (*Bacillus brevis*).

URETHRA (*Gr.*). A membranous canal conveying urine from the bladder to the outside.

UROGENITAL (*L.*). Pertaining to the urinary and genital organs.

VACCINATION (*L.*). Protective inoculation with a virus; immunization.

VACCINIA (*L.*). Cowpox. A disease of cattle regarded as a form of smallpox. When communicated to man, usually by vaccination, it confers a greater or less degree of immunity against smallpox.

VAGINA (*L.*). A sheath-like structure or canal in the female extending from the outside to the uterus. An organ of generation and also a part of the birth canal.

VASCULAR (*L.*). Pertaining to blood vessels.

VECTOR (*L.*). A carrier, especially the animal host that carries protozoal disease germs from one human host to another.

VENEREAL DISEASES (*L.*). Diseases due to or propagated by sexual intercourse.

VETERINARY (*L.*). Pertaining to domestic animals and their diseases.

VIRULENT (*L.*). Exceedingly deleterious.

VIRUS (*L.*). Any poison capable of producing disease.

VITAMIN (*L.*). One of a class of accessory food substances necessary for growth, development, and health of the individual.

VITAMIN A. A specific vitamin derived from fish-liver oils and yellow fruits and vegetables. It prevents night blindness.

VITAMIN B_1. Also called thiamin. A specific vitamin which prevents beriberi. It is found in a number of foods including pork, liver, and whole grain cereals.

VITAMIN B_2. Riboflavin.

VITAMIN C. A specific vitamin found in practically all fresh fruits and vegetables; the citrous fruits are particularly rich in this vitamin. It is not destroyed by heat except when food is cooked with baking soda added. Also called ascorbic acid.

VITAMIN D. Any of several related sterols found especially in fish-liver oils. It can be produced by the action of ultraviolet light on cholesterol (found in the human body) and ergosterol (derived from brewers yeast). It prevents rickets.

VITAMIN K. A specific vitamin which is usually produced by intestinal bacteria in man. It is also found in a few foods. Its principal function is to promote the clotting of blood.

XYLENE (*Gr.*). A solvent and disinfectant derived from wood alcohol or coal tar.

WHOOPING COUGH. An infectious disease characterized by inflammation of the respiratory tract and peculiar paroxysms of cough ending in a "whoop."

YELLOW FEVER. An infectious fever, chiefly of the tropics, marked by fatty degeneration of the liver and congestion of the mucous membranes of the stomach and intestines.

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